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The Acquisition of French Rhythm by English Second Language Learners

by

Christian P. G. Guilbault ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of

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The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled THE ACQUISITION OF FRENCH RHYTHM BY ENGLISH SECOND LANGUAGE LEARNERS submitted by CHRISTIAN P. G. GUILBAULT in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY in LINGUISTICS.

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This thesis is dedicated to my parents, Nicole and Pierre.

ABSTRACT

THE ACQUISITION OF FRENCH RHYTHM BY ENGLISH L2 LEARNERS

This study uses empirical data to investigate the acquisition of the rhythmic properties of French by native speakers of English. The data used in this study are taken from recordings of native speakers of English that were classified as intermediate or advanced L2 learners of French, native speakers of Canadian French and native speakers of European French.

The first stage of the investigation examines the hypothesis that intermediate L2 learners will exhibit more syllabic variability during the production of French than advanced L2 learners. Inter-syllabic variability was measured using a global index of durational variability which was based on the normalized duration of consecutive syllables within one rhythmic group. The results obtained suggest that, when speaking French, advanced speakers make use of temporal rhythmic structures similar to those used by native speakers of French. Intermediate learners use rhythmic structures that are overall more similar to English. Furthermore, results suggest that the syllable structures of the stimuli may have influenced the inter-syllabic variability displayed by all groups of speakers.

The second stage of the study examines the data in greater detail in an effort to narrow down the variation observed and to relate it to the phonological properties

of learners' interlanguage. The segmentation of a portion of every participant's speech into vocalic and consonantal intervals confirmed the similarities between the rhythmic structures of advanced learners and native speakers. The analysis also revealed greater variability for the duration of vowels produced by intermediate speakers. The magnitude of this variability highlights the importance of the phonemic properties of the target language in the acquisition of the suprasegmental properties of a second language.

The results of this research suggest that duration is a viable concept which can be used to define rhythm across languages. A further conclusion of this study is that rhythm is best expressed as a continuum with intermediate values rather than a binary concept. Finally, the analyses presented in this thesis emphasize the importance of considering segmental properties when providing an account of linguistic rhythm.

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1. INTRODUCTION

1.1 Statement of the Problem

The acquisition of a new phonemic system is central to the acquisition of a second language (L2). In order to explain and ultimately facilitate the acquisition of new phonemic oppositions, several models or approaches have been developed in the last two or three decades motivated by substantial empirical evidence (see chapter 2). Such models have greatly contributed not only to the explanation of the phenomenon of foreign accent but also to the elucidation of the broader phenomenon of speech perception in humans.

However, the understanding of foreign accent could be further enhanced if the existing models of L2 acquisition considered the role of the suprasegmental properties of both the second and first language (L1) . This claim is supported by the widely held view that the acquisition of such fundamental linguistic properties is of crucial importance not only to reduce foreign accent, but also to properly convey emotional information in the target language. Among the suprasegmental properties, rhythm is central to the prosodic structure of speech and, by the same token, deserves some attention.

It is the common view that rhythm provides a structure for the temporal organization of speech for both the speaker and the hearer. The temporal structure of syllables as well as the duration of each segment within the syllable are affected by the rhythmic properties of a language. Therefore, given the implications at the segmental level, it is reasonable to imagine that non-native rhythm in an L2 may hinder or even seriously challenge the communication between speaker and hearer. This problem has been identified as central to the acquisition of French as an L2 by several researchers and foreign language instructors (Valdman 1993, Freland-Ricard 1996, Kaneman-Pougatch & Pedoya-Guimbretière 1989, among others).

Despite the considerable number of linguistic accounts published on speech rhythm, there is still some disagreement about its nature. Additional research, especially from new perspectives, is required to confirm which elements of these accounts can be used as building blocks of a more satisfactory account of linguistic rhythm. The current research reported in this dissertation investigates the nature of speech rhythm from the point of view of L2 acquisition. The overall goal is to investigate what has been considered as the most important property of French rhythm, namely temporal patterns. More specifically, the acquisition of the rhythmic temporal pattern of French by native speakers of English learning French as an L2 is examined. Two questions will lead the investigation. First, do adult learners of L2 French acquire the temporal structure of French rhythm? Secondly, what are the most important acoustic properties of French rhythm?

1.2 Purpose and Significance of the Study

The investigation of linguistic rhythm is of both theoretical and applied interest. At the fundamental level, linguists seek to determine if languages are divided in two major types of timing, namely stress-timed and syllable-timed. The former type is characterized by equidistant durational intervals between stressed syllables, and the latter type by syllables of similar durations. This view has been consistently put forward in a number of studies despite the lack of convincing empirical validation (Abercrombie 1967, among others).

The results of this study will contribute to supporting the importance of duration as a fundamental property of the syllable to differentiate between the two rhythmic tendencies. The current study involves the investigation of the temporal rhythmic properties of English and French, which have been cited repeatedly as examples of either rhythmic type in many publications. This will be done through an investigation of the changes associated with the rhythmic pattern of English L2 learners of French during the acquisition process. In

addition, this research will examine the validity of an alternative account of rhythm based on the phonological properties of the languages involved.

At the applied level, studies on the acquisition of a second language, such as the Speech Learning Model and the Perceptual Assimilation Model, for example (see chapter 2), have not yet included an account of the central component of speech rhythm. The research presented in this dissertation will contribute to the foundations of a theory which will lead to the prediction of the L2 acquisition pattern of suprasegmental properties of French as L2. Also, and perhaps more importantly, this thesis will gather empirical evidence on the temporal structure of the speech of English learners of French as an L2. These data are critically needed in order to construct better curricula which include a coherent and efficient section on the acquisition of suprasegmental features of the target language. As will be shown in this thesis, the inaccuracy in the speech rhythm of intermediate learners is closely related to the duration of individual segments, especially vowels.

In summary, the goals of the study are:

a) to investigate the acquisition of French rhythm by English L2 learners;
b) to further explicate the role of duration in an account of speech rhythm; and
c) to use empirical evidence to assess certain theories of acquisition of rhythm in an L2.

1.3 Current Approach

This study takes an empirical approach and, therefore, is not designed to confirm a specific theoretical framework in phonology. Instead, the proposed investigation will examine some of the central properties of rhythm which are common to several of the proposed theoretical accounts. This is an experimental approach that attempts to discover the mechanisms underlying the use of prosodic features in language and their acquisition by adult

speakers. This approach is motivated by the work of several researchers (Brière 1966, Kohler 1981, Rochet 1995, Polka 1992, Best & Strange 1992, Logan, Lively & Pisoni 1991) who have demonstrated that proper investigations of the phenomenon of phonemic interference in L2 acquisition must rest on a thorough investigation of the acoustic properties of the sounds under study. This approach will be applied to the analysis of a corpus of French sentences produced by English speakers learning French as an L2.

The current research proposes, as a first step in the analysis, that the allegeded rhythmic differences between languages can be accounted for using a global assessment of syllabic duration variability. It is considered that the use of such an index offers an effective way of accounting for the tendency towards one of the two rhythmic types (stress-timed and syllable-timed) while capturing both the variations associated with stress assignment and syllabic variability. As a second step, an attempt is made to define with more accuracy the phonemic properties of some speech material in French as produced by English L2 learners and native speakers. This research rests on the assumption that, in the acquisition process, adult learners will attempt to acquire the most salient properties of the target language first. Traditionally, the most important rhythmic characteristic of French is the equal duration between all syllables, except the phrase-final one (but see Wenk and Wioland 1982). Therefore, the importance of duration leads to the expectation that English L2 learners of French will acquire the temporal rhythmic pattern of French early in the acquisition process. The results presented in this research will confirm that English speakers do, in fact, acquire French temporal rhythmic structure.

The experiments reported in this thesis differ from previous studies of linguistic rhythm since they investigate and compare the production of speech by English L2 learners and native speakers of French. This approach provides new insight on the nature of the linguistic rhythm and its most salient

properties. In the past, a significant amount of research and effort has been devoted to investigating the complex phenomenon of rhythm. For instance, some researchers have directly associated the rhythmic properties of a language with the durational properties of its syllables (Abercrombie 1967), whereas others have associated rhythm with stress assignment patterns (Hayes 1995). Yet another view considers that rhythm is the result of the integration of the temporal and intonational properties of an utterance (Di Cristo & Hirst 1996). In addition, it has been suggested that the rhythmic properties of a language are determined by its phonological properties (Dauer 1987, Ramus et al. 1999 among others). There is still no agreement as to which one of these approaches provides the best account of this complicated phenomenon. Results of the current investigation, however, support the use of duration in the account of linguistic rhythm. As well, the experiments present evidence that strongly suggests that language-specific phonological properties such as syllable structure and vocalic lengthening must be included in a proper account of linguistic rhythm.

1.4 Studying Rhythm: Problems and Limitations

The investigation of prosodic features in general, and most specifically rhythm, has always been a challenging task. There is no doubt that the most important factor which explains this difficulty is the inherent variability of the nature of the speech material investigated. For instance, prosody is used to provide (or reinforce) syntactic, semantic, as well as pragmatic information for each sentence. A second factor which contributes to the difficulty in analyzing prosodic properties of a language is the lack of consistency in the magnitude of the acoustic variations. It is not uncommon to observe considerable differences in intonational patterns from speaker to speaker and from one situation to another. Different dialects, sociolects, and, of course, languages also display different patterns of prosodic variation for similar functions.

The analysis of speech rhythm persents some additional challenges. Many definitions of speech rhythm such as the one proposed by Crystal (1991) claim that the rhythm of a language is the result of the "perceived regularity of prominent units in speech". These "prominent units" usually refer to stressed syllables in the speech chain. However, since this phenomenon is one of perception, it is subject to considerable individual variation. In addition, the structure of these stressed syllables is not fully understood, and even though most people seem to agree that the syllable is the proper unit of analysis, it is unknown what point in the speech continuum represents the exact perceived rhythmic "beat".

In addition, a coherent analysis of speech rhythm must take into consideration all possible aspects of this phenomenon. Meschonnic (1982) mentions three types of speech rhythm which can be construed as separate and complementary goals for a rhythmic organization in speech:

> (...) le rythme *linguistique*, celui du parler dans chaque langue, rythme de mot ou de groupe, et de phrase; le rythme *rhétorique*, variable selon les traditions culturelles, les époques stylistiques, les registres; le rythme *poétique*, qui est l'organisation d'une écriture. (Meschonnic 1982:223)

Following from this last claim, the primary function of rhythmic organization of speech by the speaker seems to facilitate parsing by the listener. However, the reconciliation between the two perspectives (from the *production* and *perception* point of view), in a similar fashion as for segmental oppositions, has yet to be fully achieved. And the relationship between linguistic speech and other biological rhythms (if there is any relationship at all) also has to be established in order to provide a coherent and complete account of this phenomenon.

The current research does not (and cannot) claim to provide a solution to all the above-mentioned problems. This study constitutes an attempt to provide empirical evidence about rhythm from the perspective and data of adult L2 acquisition. This empirical evidence helps identify the most salient properties of the rhythmic pattern of French, and thus provides additional arguments for one of the approaches available in the scientific literature. As will be explained, the results presented here support the use of duration as a fundamental property of speech rhythm. In addition, the analyses strongly suggest that other phonological properties of the language under study, such as allophonic variations of vowels for instance, must be taken into account when defining the rhythmic properties of French.

1.5 Organization of the present investigation

This study was carried out using two main analyses. Prior to discussing these analyses, a review of the literature is presented in Chapter 2, surveying the most recent research on the acquisition of new phonemic oppositions and providing an overview of the different accounts of linguistic rhythm.

Chapter 3 will present the methodology used to collect the corpora analyzed in this research. These corpora consist of a recording of French structured sentences produced by native speakers of English L2 learners of French and native speakers of French (Recall corpus in French). As well, an unstructured conversation between each participant and the experimenter was recorded to provide material for the second analysis (Free speech corpus). Finally, a third corpus similar to the Recall corpus in French was recorded in English (Recall corpus in English). Specific issues related to the measurements of the speech material as well as to the normalization of the measurements will be discussed in the relevant sections preceding these analyses (Chapters 5 and 6).

Chapter 4 will report the results of a perceptual experiment assessing the level of proficiency in production of the native speakers of English L2 learners of French. This initial step was deemed necessary in order to define with precision the level of proficiency of all learners who participated in this study. This assessment was done through a perceptual experiment where native speakers of French were instructed to classify sentences produced by the twelve English L2 learners of French who participated in this study according to a subjective evaluation of their proficiency as speakers of French. Native speakers of French were also required to classify the production of all six native speakers of French who participated in this research.

Chapter 5 describes a series of instrumental analyses of the French corpus collected for this research. These analyses include the measurement of speakers' overall syllabic duration variability using an index of duration variability in both English and French. This chapter also includes the results of additional analyses carried out to complete the investigations. For instance, the analysis investigates the effect of the position of the syllable within the rhythmic group on its duration. In addition, a comparison between two speaking styles is examined through the contrast between the syllabic duration variability found in both the Recall and the Free speech corpora.

Chapter 6 examines the effect on syllabic duration of the phonological properties of both English and French using the Recall corpus in French. In this section, a portion of this corpus is reanalyzed to confirm the preceding results while controlling for the influence of a possible non-native syllable structure associated with the speech of L2 learners of French. As well, this experiment attempts to determine if the variations in syllable duration observed in the previous analyses can be attributed to either vocalic or consonantal segments.

Chapter 7 presents the main findings of this research. It also includes a comparison between the results of the two main analyses described in

Chapters 5 and 6, in terms of their relevance to theories of L2 phonology. In addition, this section presents a discussion of the main findings of the research in relation to their contribution to better typological account of the rhythmic properties of languages. Finally, the pedagogical implications of the results are briefly discussed.

2. LITERATURE REVIEW

2.0 Introduction

It is generally accepted that few adults learning a second language reach native-like pronunciation. In order to achieve such proficiency, the speaker must acquire a set of new segmental oppositions if they are to be able to communicate efficiently in their target language. Even after several years of training or exposure to the second language, properties of the first language (L1) may persist in learners' second language (L2) and give rise to a phenomenon commonly known as *foreign accent*. The persistence of L1 suprasegmental properties in the target language is known more specifically as *prosodic foreign accent*. Prosodic foreign accent is of crucial importance as it noticeably increases native speakers' perceived foreign accent and may affect proper parsing by listeners.

Several question arise when trying to define and characterize non-native prosodic systems:

- Do L2 learners acquire the suprasegmental properties of the target language? If so, do they go through stages of acquisition?
- If speakers do not achieve native-like properties of the suprasegmental system, what features are acquired? What features are not acquired?

The purpose of this study is to provide empirical data which can be used to further explicate the answer to these questions. The conclusions made in this study are based on the investigation of the acquisition of the rhythmic temporal properties of French by English L2 learners.

A proper investigation of the acquisition of suprasegmental properties cannot proceed without first reviewing the rhythmic properties of English and

French. In this study, particular attention is paid to the models proposed for the explanation of French rhythm. The first section of this chapter presents a definition of rhythm, a review of the debate regarding the existence of speech isochrony and the most recent findings on this subject. This section also offers a review of the most important approaches to the acquisition of new phonemic systems and their pertinence for the current study. As will be shown, these approaches differ significantly in their theoretical and methodological approaches. The review also brings to light the small number of studies done on the acquisition of the rhythmic structure of an L2.

2.1 Speech Rhythm

A proper investigation of the L2 acquisition of suprasegmental properties cannot proceed without giving some attention to the broad and sometimes confusing terminology used in this field and to the various accounts of the prosodic structure of languages. Therefore, this section introduces the concept of speech rhythm and establishes the theoretical grounds on which the current research lies.

2.1.1 Defining Rhythm

Rhythm is a fundamental property of human behavior. Walking, breathing, sleeping, eating and our complete daily routine seem to be based on the common occurrence of these activities. Similarly, it seems that humans have a tendency to organize the auditory stimuli of their environment into groups of recurrent events. This can be illustrated by the natural tendency of people to group evenly spaced sounds made by water drops into sequences of two or three. Researchers have spent much time and energy in trying to properly define and account for this complex phenomenon. The current section provides a brief review of the research on the nature of rhythm in speech and in other related fields of research. As well, the most important findings in the

debate on the nature of French and English rhythm are reviewed and commented upon.

Valéry was right in claiming that defining such a complex phenomenon is not an easy task: "J'ai lu et j'ai forgé vingt définitions du rythme, dont je n'ai adopté aucune." (cited in Pineau 1979:11) The extensive review of the literature proposed by Meschonnic (1982) illustrates the complexity of this task. In this study, he examined the definitions proposed for the notion of rhythm in several types of reference material: encyclopedia, several types of dictionaries, and in many technical reference books (linguistics, poetry, philosophy). The author mentions that many of these definitions are repetitive and built on the confusion created by a false etymology. In addition, the author comments on the dichotomy between a general and more specific definitions:

> Avec parfois des nuances, avec des situations chacune particulière, toutes convergentes, ces discours (esthétique, psychologie, philosophie, linguistique, poétique, musicologique) sont un seul discours. Or ce discours est faux. Non parce qu'il serait erroné, mais parce qu'il mêle des ordres distincts, spécifiquement, historiquement: le cosmique-biologique, et l'ordre historique, qui est celui du langage. Il est faux parce qu'il se présente comme une vérité universelle – théorie unique du rythme, alors qu'il est pertinent d'une partie, et non pour le tout. Meschonnic (1982:172)

(translation provided by the author of this research)

> With sometimes subtle differences, in specific situations, all converging, these discourses (esthetic, psychological, philosophical, linguistic, poetic, musicological) are one single discourse. This discourse is false. Not because it is erroneous, but because it confuses distinctive orders, specifically, historically: the cosmic and biological, and the historical order, which is also the linguistic order. It is erroneous because it is presented as a universal truth-

> unique theory of rhythm, when it is pertinent only for a part, and not for the whole.

This quote suggests that the author considers specialized definitions too narrow in scope and unable to account for the universal phenomenon of rhythm. The difficulties associated with the formulation of a proper overall account of rhythm, however, have not prevented more researchers from providing definitions of rhythm for use within a specific field of research. Of particular interest for the current research are the definitions proposed in music, poetry and linguistics. The general definition of rhythm provided by the New Encyclopedia Britannica (1998, under "rhythm") is a good example of the ambiguity which is present in many definitions: "in music, element of time". A slightly more accurate definition is proposed in the third paragraph: "The foundation of rhythm in most music is simple: it is the regular beat." The addition of a synonym does little to inform the reader of the true nature of rhythm. The remainder of the definition, however, provides more information on the meaning of a closely related notion, namely the *meter*.

Studies on the psychology of music have the potential of providing valuable insight to clarify the notion of (linguistic) rhythm. Clarke (1999) reports that, in music, rhythm is broken down in two distinct factors: the grouping of elements and the *meter*. This conception of the musical rhythm structure has been proposed by Lerdahl and Jackendoff (1983). In fact,

> ...they pointed out that rhythm in the tonal/metric structure of the Western tradition consists of two independent elements: grouping–which is the manner in which music is segmented at a whole variety of levels, from groups of a few notes up to the large-scale form of the work–and meter–which is the regular alternation of strong and weak elements in the music. (Clarke 1999:478)

These two characteristics of rhythm should not be confused with *tempo*, which is "the rate of the pulse, or beat" (Gabrielsson 1993:109). The phenomenon of *accent* or stress also contributes to the perceptual impression of grouping by making prominent some members of a musical pattern. This definition is clearly superior to the previous one as it provides accurate information about the components of rhythm. Despite this improvement however, the exact nature of rhythm is still unspecified.

In poetry, the *meter* is not construed as the alternation between strong and weak elements, as in musical theory, but as the basic unit of analysis of rhythm. Until the end of the XIXth century, the unit of choice in French poetry was the classical alexandrine, divided in two *hémistiches* of 6 syllables by the *césure*. These units (of 6 and 12 syllables) became familiar metrical units to the readers who knew, for instance, that the *liaison* and *enchaînement* should not be made across these units but only within the meter. At the end of the XIXth century, many poets explored a variety of structures which differed from the classical meter. The contribution of the field of poetry to the notion of linguistic rhythm is mainly in the definition of the traditional notion of *meter*. In addition, it is interesting to note that a number of poets, like Mallarmé for instance, have claimed that the notion of *rhythm* cannot be separated from the more global notion of *prosody*. This view also corresponds to a recent proposal made by specialists in French linguistics (Di Cristo & Hirst 1999).

Rhythm has often been associated, in linguistics, with the metrical structure of speech. The contemporary definition of rhythm is similar to the traditional notion which is based on the regular recurrence of a specific structure. The definition proposed by Crystal (1991) in his dictionary of linguistics and phonetics illustrates this approach:

> An application of the general sense of this term in phonology, to refer to the perceived regularity of prominent units in speech. These regularities may be stated in terms of patterns of stressed v. unstressed syllables, syllable length (long *v.* short), or pitch (high *v.* low.), or some combination of these variables. (Crystal 1991)

Many researchers have spent their efforts investigating the recurring patterns of stressed syllables and provided description based on metrical structures (see for instance Halle & Vergnaud 1987 and Hayes 1995). In addition, a great deal of the early research on the rhythmic structure of languages investigated their temporal properties. Section 2.3 in the current chapter will address this issue in greater detail.

In a recent publication, Meschonnic describes the classical notion of *rhythm* as an alternation between opposing elements in speech: long or short, strong and weak, similar and dissimilar (Meschonnic 2001:724). This conception of rhythm includes, for the author, the broader notion of cosmic and social rhythm, and even the artistic production. The lack of precision in the definition proposed by Meschonnic is somewhat comparable to the one proposed by Plato ("order in the movement"). Nevertheless, this general and universal definition rests on two crucial concepts: *structure*, and *time*. The first central notion, *structure*, is intuitively connected to the notion of rhythm. In fact, the notion of rhythm has been associated with regularity, sequence, symmetry, and balance for centuries. Rhythm exists only because it is possible to see some organization of a physical reality. This organization must, in turn, allow for the identification of a specific structure which will become recurrent, bringing to the speaker a sense of regularity.

The second of the central notions of rhythm indicates the domain in which the structural activity takes place: time (Lacheret-Dujour 1999:34). The production of speech is a linear sequence of events which occurs in the

temporal domain. This allows for a relatively small amount of overlap of rhythmic events. Time is not the only domain where rhythm may bring regularity and structure. Written language, for example, occurs in a visual domain. In written language, punctuation, word boundaries, paragraphs and other visual cues are used to give structure and identify recurring events.

In sum, the various, and sometimes vague, definitions proposed for the notion of rhythm illustrate the complexity of this natural phenomenon. In the current research, the definition proposed by Crystal (1991) will be selected. Besides the fact that it is the most widely accepted and used in the field of linguistics, this definition highlights one of the most important properties of speech rhythm, namely the recurrence of a similar event. In addition, it seems important to emphasize the fact that speech rhythm also provides structure and regularity to speech in the time domain, without necessarily being limited to the recurrence of stressed syllables.

2.1.2 The Debate on Isochrony

Even in the early studies on speech rhythm, the recurrence of stressed syllables was considered central to the rhythmic properties of languages. This concept, which was at first used to describe English rhythmic properties, triggered an interesting debate that shaped the current theories about rhythm and led the research for decades to come. The present section reviews the major points of interest of this debate presented in greater detail in Couper-Kuhlen (1993).

The debate on isochrony first started with James Burnet (1774) and Joshua Steele (1775). In his essay, Burnet claimed that English had no melody. In response to this, Steele argued that English has, in fact, changes in pitch which are subject to the same rules governing its *rhythmus*. This notion of rhythm was readdressed by Daniel Jones (written in 1918 but first published in 1960), who was the first one to explicitly make use of the notion of isochrony in

speech. He claimed that isochrony is a fundamental property of the English language: "[t]here is a strong tendency in connected speech to make stressed syllables follow each other as nearly as possible at equal distances." (1960:237) Jones then goes on to give a more detailed explanation based on the duration of monosyllabic and disyllabic words. To him, vowel length in a stressed syllable is closely tied to the presence of another stressed syllable immediately following it or to the number of unstressed syllables following it. If the time interval remains the same between stressed syllables, *eight, nine, ten* will have vowels which are twice as long as in *eighteen, nineteen, twenty*.

Pike (1945) reused Jones' concept of *isochrony* in his book called *Intonation of American English*. He defines the rhythmic unit as "[a] sentence or part of a sentence spoken with a single rush of syllables uninterrupted by a pause". (1945:34) Like Jones, he sees the uniform spacing of stresses in one rhythmic unit as governing the necessity to make syllables shorter in groups which have more syllables than in groups which have fewer syllables. It is also in this book that Pike proposed the classification of rhythmic units in two distinct categories: *syllable-timed* and *stress-timed*. The latter refers to languages that exhibit equal time between stressed syllables, and the former describes languages that exhibit equal timing across all syllables. However, it is interesting to note that Pike considers that both types of rhythm exist in English even though syllable timing may only occur in very special circumstances, like spoken chants.

Abercrombie (1967) attempted to take Pike's classification of rhythmic units one step further. He proposes that all languages can be classified either as stress-timed or syllable-timed. Dauer (1983) goes even further and established the following classification for natural languages:

STRESS-TIMED	*SYLLABLE-TIMED*[1]
English	French
Russian	Spanish
Germanic languages	Yoruba
Arabic	Telegu
Thai	Hindi
Brazilian Portuguese	Tamil
Newari, Chepang, Gurung, Tamang	Indonesian
	Japanese

The most important consequence of stress isochrony is that duration of interstress syllables will have to be modified in order to satisfy the timing constraint. This property is illustrated with the following textbook example (Couper-Kuhlen 1986:57):

(1) 'This is the | 'house that | 'j a c k | 'b u i l t .

Sentence (1) is considered as having four rhythmic units which, according to the terminology proposed by Abercrombie (1964), are called 'feet'. A 'foot' contains one stressed syllable and all following unstressed syllables. Feet in stress-timed languages are of approximately equal duration. In this example, the monosyllabic words 'jack' and 'built' would have to be noticeably longer than the other syllables in the preceding feet. In other words, syllables in the first two feet would have to be *compressed* whereas syllables in the last two feet would have to be *stretched* in order to have feet of equal length. This tendency for syllables to be compressed or stretched does not mean that all syllables have equal duration within one foot.

In addition to stress-timed and syllable-timed languages, a third type of rhythm is proposed in the literature: the moraic rhythm. This third category of linguistic rhythm was motivated by a need to account for Japanese, which does not seem to readily fit within the other two categories. It is interesting to note

[1] Italian could be added to this category. The reader can refer to Couper-Kuhlen (1993:10) for details.

that Japanese was initially classified as a syllable-timed language by Abercrombie (1967). Rhythm in Japanese is based on the existence of a unit of time called *mora*. The mora, which has been borrowed from the theory of verse applied to Greek and Latin, is defined as a unit or measure of length comparable to a short syllable with a CV structure[2]. Long syllables can be assigned two *morae*.

Japanese seems to be the only language associated with this rhythmic class. In this language, one mora is assigned to consonant-vowel sequences (to-ko-ro). The originality comes from the possibility for geminate consonants (ta-t-ta), long vowels (te-e-bu-ru), and syllabic nasals (sa-n) to be assigned one mora. However, it has proven impossible to provide empirical evidence to support the hypothesis of a strict equality between the duration of moras. Instrumental analyses by Hoequist (1983) on Japanese and Spanish have revealed a loose connection between the existence of rhythmical units and their phonetic duration. It is worthy of mention that other units of analysis have been proposed for the explanation of Japanese rhythm. Poser (1990), for instance, proposed that, not unlike stress-timed languages, the timing of Japanese is based on the existence of a structure called the bimoraic foot, which is similar to the foot found in stress-timed languages. Empirical evidence for the support of such a hypothesis has yet to be provided.

Linguists hoped to find instrumental evidence of this typological classification of natural languages into two clearly distinct categories. Couper-Kuhlen (1993) reports that Classe (1939), using the kymograph, was the first researcher to investigate isochrony in English. Measurements of duration between stressed syllables were taken on recorded sentences. His results did not support the isochrony hypothesis. Strict isochrony was found only under

[2] There has been some confusion regarding the exact definition of the mora. In fact, it has been associated with the length of the vowel, or the length of the syllable. The reader can refer to the Fox (2000:46-50) for a more detailed review.

very special circumstances. This was when rhythmic groups were similar in almost all aspects, i.e., had similar number of syllables with similar phonetic structure and grammatical structure. Classe then concludes that "isochronous groups must be rare in English prose" (Classe 1939:90). This negative conclusion has been confirmed by many subsequent experiments: Shen and Peterson (1962), Bolinger (1965), O'Connor (1965).

Another study, by Uldall (1971), attempted to measure the inter-stress intervals in order to determine isochrony in English. The material measured was a written passage read by Abercrombie. Once again, the measurements did not mark regularity. Acoustical evidence also cast some doubt on languages that have been labeled by researchers as belonging to one of the two language categories. Spanish for example was considered as being syllable-timed (Pike 1945 and Hockett 1955). Studies by Alvarez de Ruf (1978) and by Balasubramanian (1980) reported experimental evidence of attribution of the wrong label respectively for Chilean Spanish and Tamil. As well, Miller (1984) reported a perceptual experiment where Spanish was judged as being stress-timed by native English and French speakers instead of its initial classification as a syllable-timed language.

The existence of isochrony in English has been challenged once more in a recent study by Crystal and House (1990). In this paper, the authors report the results from an instrumental analysis of the production of two English scripts (about 600 words) by 6 participants. The main goal of their experiment was to determine if English, defined as a stress-timed language, exhibits syllable compression in feet which include more syllables. Their results show that the average syllabic duration is dependent essentially on the stress condition and the number of its phones. More specifically, their data did not provide evidence of noticeable compression, measured in the duration of the stressed syllable or stressed vowel. Another important result is that the length of additional unstressed syllables added to a stress group without pause is

constant. The existence of isochronous stress groups would have predicted an important compression effect to maintain the constant duration of the stress group. The seemingly unquestionable results have to be put in perspective due to the possibility that speech material may have a different prosodic organization than free speech (Guaïtella 1999). Nevertheless, this weakens the possibility of finding compressed syllables in English and in any other stress-timed language.

It was later argued that if isochrony, considered as the return of rhythmic beats at an identical time interval, does not exist in any natural language, it must be an acoustic "impression". Dauer reports that Lehiste (1977), Donovan and Darwin (1979) "found that listeners tend to hear interstress intervals in English as more isochronic than they really are" (Dauer 1983:55). In his investigation of isochrony, Roach (1982) came to a similar conclusion. He tested two specific claims made by Abercrombie (1967): (i) 'there is considerable variation in syllable length in a language spoken with stress-timed rhythm whereas in a language spoken with a syllable-timed rhythm the syllables tend to be equal in length', and (ii) 'in syllable-timed languages, stress pulses are unevenly spaced' (Roach 1982:74). His results came from measurements of inter-stress intervals in the recording of a passage read by Abercrombie.

The results did not show regular inter-stress intervals or even the distinction between languages in two categories based on this sole criterion. If the previous classification of languages in two categories was correct, then speakers of both types of languages should exhibit different tendencies in a perceptual experiment. Speakers of stress-timed languages should "expect" to regularize interstress intervals, whereas speakers of syllable-timed languages should expect to regularize duration between syllables.

However, Scott, Isard, and de Boysson-Bardies (1985) showed that there is a tendency not only in English but also in French to regularize inter-stress intervals. More doubt was cast on the concept of isochrony by a study that investigated the syllable-timed characteristic of French. In their study, Wenk and Wioland (1982) found that rhythmic-group final syllables are nearly twice as long as non-final syllables. Similar evidence was provided by Allen (1975, 1979), Lehiste (1977), Donovan and Darwin (1979).

Perceptual centers (or *p-centers*) were then introduced as another way to explain the perceptual impression of isochrony. This phenomenon was investigated by Morton et al. (1976) who introduced the term P-centers. Morton found that when asked to perceptually align two regularly occurring stimuli, listeners tended to align them according to different points in time. For example, listeners would align the word *one* produced at regular intervals with another word, say *two*, by manipulating knobs that would advance or retard the occurrence of the second word. It was found that listeners would vary in their alignment of different words, but that they would be consistent in the temporal placement of the same words. This effect has since been replicated in several studies (Tuller & Fowler 1980, Hoequist 1983, Fox & Lehiste 1987, Cooper, Whalen & Fowler 1986, 1988).

The results obtained by Morton are important to the investigation of speech isochrony since they demonstrate that speakers are able to relate the perception of different stimuli with discrete points in time. This is consistent with the isochrony hypothesis. Even though Couper-Kuhlen (1993) makes a strong case for p-centers, this new proposal is greatly challenged by the fact that it has been impossible to relate these perceptual points to any accurate moments or acoustical events in time.

Conversely, the notion of isochrony has recently been used successfully in the characterization of different dialects. In a study which investigated the

differences between Singapore English and British English, Deterding (1994, 2000) used an index to determine if the durational pattern of both languages would describe adequately the perceived rhythmic differences between the two dialects. The amount of inter-syllabic durational variability for each language was computed with an index which compares the duration of each syllable to the average syllable duration in a sentence (the computation of this index is explained in section 5.1.4). The author found that speakers of Singapore English displayed a significantly lower index, which indicates less variability in their syllable durations, when compared to speakers of British English. This was interpreted as evidence that speakers of Singapore English exhibit a rhythmic pattern closer to the one attributed to syllable-timed languages. This result also suggests that differences in linguistic rhythm could be related to the durational properties of syllables. A similar approach will be used in the current study. As will be shown, results will support the use of the durational properties of syllables, in conjunction with other phonemic properties, for the account of the alleged two main categories of linguistic rhythm.

The original typological account of speech rhythm associated languages to only one of three types of timing, namely stress-timed, syllable-timed, or moraic. However, it is now considered by many researchers that speech rhythm is subject to variations according to speaking styles (Astésano 1999, Guaïtella 1991), and dialects (Deterding 1994, 2001) for example.

This view is supported by empirical evidence demonstrating the existence of differences in perception of primary stress in different dialects. For example, Dolbec and Santi (1995) and Deshaies et al. (1994) have shown the importance of the linguistic "sieve" in the perception of stressed syllables. The existence of only three categories is also being challenged by empirical evidence which suggests that speech rhythm can be the result of opposing timing tendencies in one language. In addition, the assignment of stress can be modified to avoid stress clash ('principe d'eurythmie', see Dell 1984).

Rhythmic properties of French for instance are the result of a tendency to produce syllables of equal durations, and a tendency to produce regular rhythmic groups (Astésano 1999, Guaïtella 1999). This evidence argues for the need of a more detailed account of the phenomenon of rhythm which would situate languages on a scale according to their tendency toward one rhythmic type or the other.

2.1.3 The Role of Language-Specific Phonemic Properties

Such an approach was fleshed out in a recent empirical study (Ramus et al. 1999). This hypothesis, which was first proposed by Dasher and Bolinger (1982), rests on the claim that linguistic rhythm is not considered dependent solely on inter-stress intervals. Rather, it is considered as the result of the interaction of language-specific phonemic properties reflected at the phonetic level. These properties contribute to the differences in timing observed between classes of languages, and, hence, are responsible for the perception of two major classes of rhythm.

Among the properties which differ from stress-timed and syllable-timed languages, Dauer (1983) mentions the syllable structure and vowel reduction as the most influential ones. It is alleged that the syllable structure of the stress-timed languages tends to be more diversified than in syllable-timed languages. This greater diversity results in an increased number of consonants in the signal which, combined with the fact that stress tends to fall more often on heavy syllables, is responsible for a larger proportion of time spent producing consonants than vowels. In addition, the phenomenon of vowel reduction in stress-timed languages shortens the duration of unstressed syllables which, in turn, greatly affects the nuclei.

Empirical evidence to support this hypothesis comes from Ramus et al. (1999). For the authors, rhythmic classes can be accounted for by a straightforward segmentation of the speech signal into consonants and vowels.

In their study, the authors investigated the proportions of both segments in eight different languages: English, Dutch, Polish, French, Spanish, Italian, Catalan, Japanese. The interest of this study is twofold. First, it provided new empirical evidence to support the hypothesis which relates the differences in rhythmic classes to language-specific phonemic properties. Second, the authors provided a methodology which allows for a comparison between languages regarding their rhythmic characteristics. This comparison has the main advantage of allowing an accurate measurement of the rhythmic properties of a language and its location on a continuum (or plane) which includes intermediate values. As will be seen, this methodology is also appropriate to investigations of suprasegmentals in L2 acquisition.

2.1.4 The Comb and The Chain Models of Speech Timing

The existence of isochrony at the cognitive level has been investigated in an attempt to uncover the mechanisms underlying the temporal regulation of speech. It has been suggested that speech timing could be explained by one of the two competing models called the Chain and the Comb models (Kozhevnikov & Chistovich 1965). These two models offer a different account of speech timing based on the transmission of information from the brain to the peripheral motor organs. The basic difference between the two models is, in simple terms, that in the Comb model, there is no monitoring of speech through sensory feedback allowing to determine when the next speech event should occur. On the contrary, the Chain model proposes that sensory feedback is used to determine the realization of the next speech gesture.

For Kozhevnikov and Chistovich, it should be possible to determine which model is valid by measuring the amount of variance in time which originates from two different transmission paths between speech events. These speech events represent the time needed for impulses to go from the brain to the peripheral motor organs. In the case of the Chain model, the variance between two speech events should be similar to the sum of its

component intervals (events y1, z1, x2 in Figure 2.1). To the contrary, in the Comb model, the variance between two speech events should be smaller than the sum of its component intervals (x1, z1, x2 in Figure 2.1). The different paths of the speech events will produce differences in the amount of variance measured for a series of speech events.

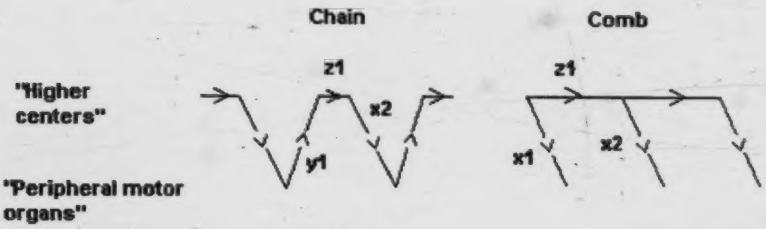


Figure 2-1 Representation of the Chain and the Comb models (after Ohala 1975:436)

The experimental evidence reviewed by Ohala (1975) in support of either model appears controversial. In addition, it appears that some of this evidence is tainted by noise related to the methodology used or to variations in speech rate, for instance. The empirical evidence reviewed in Ohala's paper reveals that in small sub-intervals, the variance of the whole interval is smaller than the sum of the variance of its parts. Conversely, Ohala's experiment demonstrated that, in large intervals, the variance of the whole interval is greater than the sum of the variance of its parts. Based on this, Ohala concludes that a hybrid model which favors the use of the Comb model for short intervals of speech, and the Chain model for longer stretches of utterance would be more appropriate. Evidently, these two models need to be carefully and thoroughly investigated before any claim can be made with an acceptable degree of certainty and before they can be applied to characterize languages based on their temporal rhythmic properties.

2.1.5 Summary

Despite the lack of consensus on a proper definition of the broad phenomenon of rhythm, the nature of linguistic rhythm seems to the equated with a recurrence of stressed syllables, and with the concepts of *structure* and *time*. Traditionally, languages have been defined as belonging to one of three classes according to their timing properties: stress-timed, syllable-timed, and moraic. It is unclear at this point what acoustical properties are associated with each typological category. Empirical evidence has, however, emphasized the role of syllabic duration as a fundamental property of rhythm. The debate on the nature of speech rhythm seems to have now shifted from the determination of inter-stress intervals to the determination of durational properties of languages which are presumably motivated by language-specific phonemic properties.

2.2 Rhythm in French

There are several accounts of French rhythm available in the literature. These accounts differ mostly in their theoretical assumptions and the methodology used in predicting the rhythmic structure of an utterance. This chapter will introduce the most important approaches and will highlight their significance in the ongoing debate about the nature of French rhythm.

2.2.1 Rhythm and Stress Assignment

In linguistics, the presence of rhythmic beats in natural languages has often been attributed to the presence of stressed syllables (Crystal 1991). For this reason, many researchers have attempted to predict stress placement in an effort to provide a satisfactory account of the rhythmic organization of speech. This section presents a summary of such attempts and a discussion of their application to the French language.

Prior to presenting the various attempts that have been made to explain and predict stress placement, it appears necessary to provide some essential

information on the complex notion of *stress*. This phenomenon, which is closely related to the phenomenon of *accent*, is one of the most controversial ones in the study of prosody. Many scholars have debated its phonetic nature, its role in phonological theories and its relationship to morphology and syntax, giving rise to a number of different and sometimes incompatible accounts. The role of the following paragraphs is not to provide an exhaustive overview of all the different proposals[3], but merely to clarify the meaning of the word *stress* and its importance for the analysis of rhythm.

In his *Dictionary of Linguistics and Phonetics* (1991), Crystal defines the term *stress* as the "degree of force used in producing a syllable". Syllables which are stressed are considered more prominent in speech than syllables which are unstressed. *Stress* must be differentiated from the broader notion of *accent*, considered as "the most neutral superordinate term, to refer to the linguistic phenomenon in which a particular element of the speech chain is singled out in relation to surrounding elements, irrespective of the means by which this is achieved." (Fox 2000:115) In agreement with Beckman (1986), Fox considers that *stress* (or stress-accent) is phonetically realized by variations of "a number of phonetic features, but *not* exclusively pitch" (Fox 2000:126), where *accent* (or non-stress accent) is perhaps exclusively based on variations in pitch. Stress is found in languages like English and Dutch, and accent, a relatively rare phenomenon, is found in Japanese for instance (Beckman 1986).

Fox (2000) explains that because of the changing nature of accent within and across languages, a distinction based solely on phonetic descriptions is not adequate. A more complete account of the differences between these two phenomena can be provided using phonological properties. Accent has an organizational role which is manifested in two different ways at

[3] The reader can refer to Fox (2000) for a detailed review of the general phenomenon of *accent*.

the phonetic level: stress accent (as in English and Italian for instance), and non-stress accent (as in Japanese). This distinction is important in the sense that it differentiates between the more general phenomenon of accent, which organizes speech into "units in which the accentual contrasts operate", and its manifestation in the system of a specific language (stress). In the current research, the term *stress* will be used to indicate any manifestation of the more general phenomenon of *accent*.

Research in prosody has identified three distinct uses of stress (Paradis 1993:10). First, stress is used to mark lexical contrasts in languages which have lexical stress like English, Italian, and Spanish. In English for instance, such contrasts are found in word pairs like 'subject (n.)- sub'ject (vb.), 'record (n.), re'cord (vb.), 'present (n.), pre'sent (vb.), etc. French, as opposed to other Romance languages, does not exhibit such a property. Second, stressed syllables can act as a boundary marker, allowing a speaker to define and to integrate words or groups of words into an organized structure. It can be used to group lexical items which share a syntactic and semantic relationship (Martin 1979, 1987). Stressed syllables can also be used to facilitate decoding of syntactically related units (Dell 1984). For instance, the two phrases below are solely distinguished by stress placement (in the examples, the relative perceptual salience of the accents is noted above the syllables; the closer to 1, the more salient they are):

(2)	l'au-	ber-	gine	es-	pé-	rée
			2			1
(3)	l'au-	berge	i-	nes-	pé-	rée
		2		3		1

Third, it can be used to enhance a specific part of the message which is considered relevant for pragmatic purposes. For instance, one can focus on

the initial syllable of a lexical item to emphasize its opposition to another lexical item, as in examples (4) and (5) below:

(4) English: "I meant to say 'unrelated, not 'related."

(5) French: "Je voulais dire 'apériodique, et non 'périodique."

There is more than one degree of stress. Most languages have at least two distinct types, called *primary* and *secondary*. In French, primary stress is also called *logical*, *tonic*, *normal*, *internal*, *objective*, or *"nucléaire"* (nuclear), and is the one which is easiest to perceive. It is generally considered that primary stress in French falls on the last full syllable of the last lexical item of a stress group. This unit, the *stress group*, may contain one or more lexical items, as in examples (6) to (9):

(6) [Alfred]$_{NP}$ est monté dans l'arbre.

(7) [Le 'chat]$_{NP}$ est monté dans l'arbre.

(8) [Le chat 'gris]$_{NP}$ est monté dans l'arbre.

(9) [Le petit chat 'gris]$_{NP}$ est monté dans l'arbre.

In English, the American Structuralist tradition distinguishes between four degrees of lexical stress: *primary* (strongest), *secondary*, *tertiary*, and *weak* (weakest). Such fine distinctions can be illustrated in example (10) below (Crystal 1991):

(10) *1 4 3 4 2 4 3 4*
el e va t or op e ra t or

In (10), the first syllable *el-* is associated with the strongest stress mark. This type of stress (acoustically marked in French by a noticeable increase in duration and intonation, as in examples 6 to 9 above) has been described as *phrasal stress* by many authors (Grammont 1933, Nyrop 1955, Marouzeau 1956, Sten 1963, Garde 1968). The regularity in the placement of this stress has led researchers to propose that French is marked by a close relationship

between syntax and stress placement (Martin 1979, 1987). For Dell (1984), primary stress placement is determined by the strength of the syntactic boundary that follows a lexical item. However, using a syntactic criterion does not provide a satisfactory account of the phenomenon of stress placement in French. Metrical grids, developed to predict stress placement in English, have also been applied to French with relative success (Paradis & Deshaies 1991). These grids rely on an alternation between stressed and unstressed syllables (Verluyten 1984, Dell 1984).

The location of secondary stress in French, also called *accent intellectuel, rhythmique,* and *ictus mélodique,* is still debated by researchers. Many authors consider that it falls on the primary syllable of a trisyllabic content word like *considère*, or *permanent* for instance (Vaissière 1974, Hirst & DiCristo 1984, Milner & Regnault 1987, Pasdeloup 1990). Its acoustic correlates are an increase of intonation only. This initial stress, which should not be confused with emphatic stress, serves to keep rhythmic balance (Pasdeloup 1990). In *chaton gris* (Lacheret-Dujour & Beaugendre 1999 :44) for instance, the stress mark on the second syllable of the word *chaton* is moved on the first syllable in order to avoid two consecutive stressed syllables. This tendency in French has also been described by Fonagy (1979 cited in Di Cristo 1998:198) who called it a *centrifugal force*. This force contributes to the semantic and syntactic cohesion of a phrase by attracting primary stress on the last full syllable of a phrase-final word and a secondary stress on the first full syllable of the first lexical item of a phrase, as in: *la MA-jeure par-TIE.*

The following section will examine some of the most interesting and important accounts of stress assignment in French.

2.2.2 Models of Stress Assignment in French

Several accounts of stress placement have been developed for French. This section will introduce three of the most important approaches and

highlights their strengths and weaknesses. The first interesting account was proposed by Martin (1979) who examined the possibility that the placement of primary stress is solely dependent on the syntactic and semantic properties of an utterance. This model is important because it constitutes the first comprehensive model of stress assignment in French. In the second account presented, stress placement is integrated to a greater theory of intonational variations by Di Cristo and Hirst (1993, 1997). Finally, the third model introduced represents an Optimality Theory account of the rhythmic structure of French (Delais-Roussarie 1995). These models are briefly presented and commented on in the upcoming sections.

2.2.2.1 Direct Relationship Between Syntax and Stress Assignment

One of the first comprehensive models for the prediction of stress in French has been proposed by Ph. Martin (1980, 1986, 1987). His account of stress placement based on the syntactical structure of an utterance marks a noticeable departure from previous analyses which were based on the morphological properties of French (Fonagy 1979, Garde 1968).

Such an approach was proposed by Garde (1968), who suggested dividing French into 'words' (verbs, names, adjectives, etc.), and 'clitics' (pronouns, prepositions, conjunctions, etc.). Elements belonging to the former category, according to the author, can generate stress, whereas elements belonging to the latter class cannot. Clitics are associated with the preceding or following word and form the minimal stress unit, in which the final syllable will bear stress. For instance, in example (11), *prends* is stressed (as indicated by the " ' ").

(11) Tu le 'prends.
(12) Prends-'le.

Ph. Martin rejects this analysis on the basis that it would not account for sentences where the pronoun is in final position, as in (12). The author suggested instead that the prosodic structure is generated based on the semantico-syntactical relationships between lexical elements. For instance, he justifies the optional stress on *qui* in examples (13)-(14) below by the existence of a different syntactic relationship in different structures (cited in Lacheret-Dujour & Beaugendre 1999:123). In (14), *qui* would require stress but not in (13):

(13) Pierre qui est venu ce matin a vu Marie.
(14) Pierre 'qui ce matin est venu a vu Marie.

Central to the assignment of stress are the syntactic relationships between lexical items. These relationships are:

a) *independence*: the items are not dependent on each other, as in [Hier] [Luc est parti];
b) *mutually bound* ("solidarité"): the two items are dependent on each other, as in [*est parti*];
c) *selected* by an item *on its left*: the item on the right depends on the item on its left in the speech chain. In [*Luc*] ? [*est parti*], the unit [*est parti*] selects [*Luc*]; or
d) *selected* by an item *on its right*: the item on the left depends on the item on its right in the speech chain. In [*jeune professeur*], [*jeune*] selects the noun [*professeur*].

The four rules below, R1 to R4, account for the *simple* (as opposed to *complex*, see below) syntactic relationships described as by the author:

R1: in a group of two subsequent units or more, where one unit *selects* (syntactically or semantically) only one more unit (→,←), all of them can bear stress:

(15) [agré'able] → [ba'teau] ; [ba'teau] ← [agré'able]

(16) ['Pierre] ['aime] [Ma'rie]

R2: if two units are syntactically bound (↔), they form a single stress unit and will therefore have only one stressed syllable:

(17) [le ↔ ba'teau]

(18) [il ↔ écou'tait]

R3: if an intermediate unit is bound to its surrounding elements, a single prosodic unit will be formed in a two-step process. In the following example, the first unit will be formed by joining *mangé* to *a*, and then *a mangé* to *il*.

(19) [Il ↔ a man'gé]

R4: if an intermediate unit depends on the right and the left elements, two stress units are formed.

(20) ['Pierre] ↔ [et Mar'ie]

Martin adds four more rules which describe more *complex* (or *long-distance*) syntactic relationships between lexical items. Stress is assigned according to the type of dependency relationship items have between each other.

R5: "Distance Dependency": it is not possible for two syntactically dependent items to be connected at the prosodic level when an element, which has no dependency relationship with the first or the second element, is inserted between these original two units.

(21) [Pierre $_A$] ['est $_X$] [je 'crois $_B$] [ve'nu $_C$]

In (21), the close relationship between items A, B, and C (*Pierre est* and *venu*) is suspended by the presence of the element B. In this case, items X and C constitute an independent stress unit.

R6: "Double Dependency": A double dependency relationship between three items occurs when items A, B, and C are all dependent on each other. These items will be divided based on the greater strength of the dependency between two of them. Thus, the grouping can be either between items A and B, or between items B and C. If item A selects item B, items B and C will be stressed (going from left to right). If item B selects item C, then A and C will be stressed (going from right to left). For instance, example (22) illustrates the case where the double dependency goes from left to right, and where the underlined syllables will be stressed.

(22) [De $_A$ Ma'rie $_B$] [il se sou'vient $_C$]

R7: "Multiple Interdependence": This type of relationship occurs when several items are interdependent. In these cases, the last item always gets the stress.

(23) [*avez* ↔ *vous* ↔ *com'pris*]

R8: "Double Mixed Presupposition" (*Double présupposition mixte*): When one syntactic item is bound to another item, but also select another one.

(24) ['Pierre $_A$] [qui $_B$ 'roule $_C$] n'amasse pas mousse.

In (24), items B and C form a single accentual unit, which in turn selects the preceding item A. In syntactic constructions of this type, the first (A) and the last (C) items are stressed.

This model has one important shortcoming: it does not consider any other accent, like the secondary or rhythmic accent in the assignment of the rhythmic structure. As well, the authors admit that it is not possible to assign stress based solely on the syntactic properties of a sentence. Therefore, Martin (1986) proposed to use an 'index of disrhythmicity' which allows the construction of a proper rhythmic structure even when the syntactic criteria are in conflict with the rhythmic ones.

This model of stress assignment in French proposed by Martin (1980) is important in the sense that it represents the first serious attempt at defining the rhythmic structure of French. Its most interesting characteristic is the close relationship between the syntactic and prosodic properties of an utterance, which are generally accepted as central to the production of stressed syllables in French.

2.2.2.2 The Approach Proposed by Di Cristo and Hirst (1993, 1996)

The model proposed by Di Cristo and Hirst (1993, 1996), is based on the central idea that the rhythmic structure of a language is defined by a combination of the *intonational* and *temporal* structures of the utterance. Thus, contrary to the previous approach, the syntactic structure constitutes only one of the factors which determines the overall prosodic properties of a sentence. This model marks a change from the previous approaches particularly because it integrates two types of prosodic parameters, namely intonational and temporal, which have been kept independent up to this point in order to predict the rhythmic structure of French.

For the authors, tone and free-stress languages have rhythmic information specified in the lexicon and fixed-stress languages like French need rules to create a rhythmic structure. In order to derive the rhythmic structure of an utterance, the proposed model uses a combination of rules, a

phonological tree, and a metrical grid. The first step of this process requires the generation of prosodic units using the following three post-lexical rules:

R1: IU (Intonation Units) are delimited by major syntactic constituants
R2: TU (Tonal Units) are formed by a series of syllables up to and including the initial syllable of a lexical item ('proéminence initiale'),
R3: RU (Rhythmic Units) is constituted by a series of syllables up to and including the final syllable of a lexical item ('proéminence finale'),

Speech rate and pragmatic constraints may require the use of a fourth rule, called a *readjustment rule*. This may be needed in order to adjust the stress patterns generated previously to avoid stress clashes.

R4: when a monosyllable stress group is both preceded and followed by a stress syllable in the same IU, combine the last two groups into one.

For instance, in example (25), the stress on the word *chat* must be transferred on the preceding word to attain the structure presented in (26):

(25) [Un 'beau | 'chat | 'gris] (a beautiful grey cat)
(26) [Un 'beau | chat | 'gris] (a beautiful grey cat)

The application of the basic rules R1-R3 on the sentence "mon fils et son voisin se sont disputés" is done through the generation of high (H for *haut*) and low (B for *bas)* tonal segments. This ensures the formation of proper tonal units, as illustrated in Figure 2-1:

IU	(mon	fils	et	son	voi-	sin)	(se	sont	dis-	pu	tés)
RU	*(mon*	*fils)*	*(et*	*son*	*voi-*	*sin)*	*(se*	*sont*	*dis-*	*pu*	*tés)*
TU	(mon	fils)	(et	son	voi-	sin)	(se	sont	dis-)	(pu	tés)
ITS	(B					H)	(B				B)
RTS	(B	H)	(B			H)	(B				H)
TTS	(B	H)	(B			H)	(B		H)	(B	H)

Figure 2-2 Tonal units of the sentence "Mon fils et son voisin se sont disputés." as defined by Di Cristo and Hirst (1993).

where:

-IU = the intonation unit ('unité intonative'),
-RU = the rhythmic unit ('unité rythmique'),
-TU = the tonal unit ('unité tonale'),
-ITS = the tonal segments for IU ('segments tonals des UI'),
-RTS = the tonal segments for RU ('segments tonals des UR'), and
-TTS = the tonal segments for TU ('segments tonals des UT').

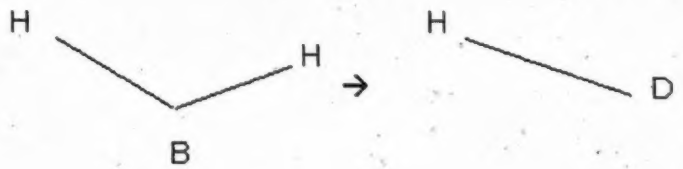
The tonal segments proposed after this first step in the analysis are based on the production of high and low tones. These basic tone movements, which are formed partly on the presence of primary stress, form the tonal structure of the utterance. In some cases, this structure is going to be impossible to pronounce and an additional set of three rules (R5, R6, and R7) is going to be required. These three rules will ensure proper final tonal contours:

R5: Downstep rule determines that a high tone will be lowered if it is preceded by a high tone followed by a low tone. Subsequently, the low tone which preceded a downstepped tone (D) will be deleted.

$H \rightarrow A / HB$ --

$B \rightarrow 0 /$ -- A

This modification of the basic contour will be realized as below:



The representation of different prosodic groupings on different levels (ITS, RTS, TTS) requires a rule which projects all variations on a single line. The last rule ensures that no tonal variations are repeated within the same tonal unit.

> R6: A *linearization* rule copies tones assigned to the higher rank (IU) to appropriate units which, otherwise, would be on different levels.

> R7: A *tone simplification* rule avoids the occurrence of two identical TTS within the same TU.

The modifications caused by the last three rules are shown in the following example (Lacheret-Dujour & Beaugendre 1999:141):

A	(B	H)	(	A	)	(B	H)	(	A	)
L	((BB	H)	(A		H))	((BB	H)	(A		B))
S	(B	H)	(A		H))	((B	H)	(A		B))

where:

-A refers to the Downstepping rule,
-L refers to the Linearization rule, and
-S refers to the Simplification rule.

These tonal variations should provide a realistic tonal pattern for the production of the previous sentence. However, the final form will only be achieved after this structure has been completed by the metrical representation of the syllabic prominences of this sentence. These prominences determine

the limits of the prosodic constituents which have been defined in the first step of the analysis. Rhythmic units constitute an intermediary level used in the determination of the final prosodic contours of the utterance. The structure of the sentence under study is as follows:

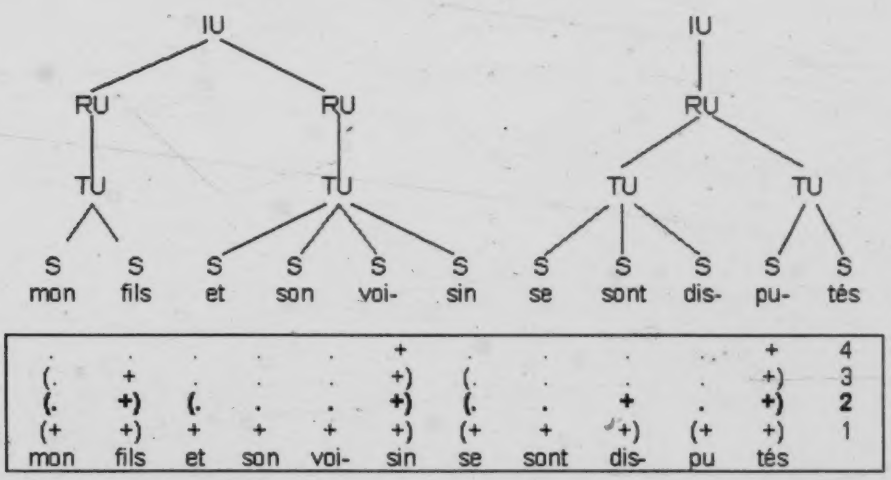


Figure 2-3 Phonological tree and metrical grid for the sentence "Mon fils et son voisin se sont disputés." according to Hirst and Di Cristo's analysis (from Lacheret-Dujour & Beaugendre 1999:142)

where:
-S refers to syllable,
-line 1 (right of the grid) presents the tonal units (TU),
-line 2 presents the rhythmic units (RU),
-line 3 presents the intonational units (IU), and
-line 4 presents the highest level or representation.

This fairly extensive analysis proposed by Di Cristo and Hirst has the advantage of offering an account based on the interaction of the intonational and rhythmic variations in an utterance. It is my opinion that these two phenomena should be related and that a comprehensive account of rhythm should integrate variations of these two parameters. However, it is undetermined at this point how this approach can account for variations in the rhythmic structures according to speaking styles and dialects. As previously

explained, these variations have become central to the investigations of the nature of rhythm.

2.2.2.3 An Optimality Theory Account of French Prosodic Structure

Like the previous model, the account proposed by Delais-Roussarie (1995) integrates constraints imposed by several levels of factors in order to explain the prosodic properties of French. The framework of Optimality Theory (OT), developed by Prince and Smolensky (1993), allows for a modular approach of this type. The following paragraphs will briefly describe the model and the constraints proposed by Delais-Roussarie.

The overall goal of OT is to account for the mechanisms of specific languages based on the principles of Universal Grammar. This specific framework provides an environment where the value of an *input* form, as generated by the function "GEN", is evaluated by the module "H-eval" according to the a set of constraints defined by Universal Grammar. The ranking of these language-specific constraints will determine the preferred form called the *output*. Violations of higher-ranked constraints are more likely to rule out a potential form than the violation of lower-ranked constraints.

In the model proposed by Delais-Roussarie, several independent modules contribute to the formation of a grammar of French prosody. These modules provide information about the rhythmic, semantic, phonemic, and syntactic properties of a sentence through specific representations from each module (R_{rythm}, R_{sem}, R_{phono}, R_{synt}). The information from these four independent modules is then evaluated, treated, and integrated by the Prosodic Interface. The evaluation of the proper output forms by this interface rests on the hierarchy of the proposed (and sometimes conflicting) constraints. The overall organization is represented in Figure 2.4.

Two types of constraints are required for the production of proper output: faithfulness ("*contraintes fondamentales*" in Delais-Roussarie), which are universal, and markedness ("*contraintes de bonne formation*" in Delais-Roussarie) which are language-specific. The former constraints ensure that the output form preserves the properties of the input form, while the latter requires that the output form meets the requirements related to the principles of well-formedness of that specific language.

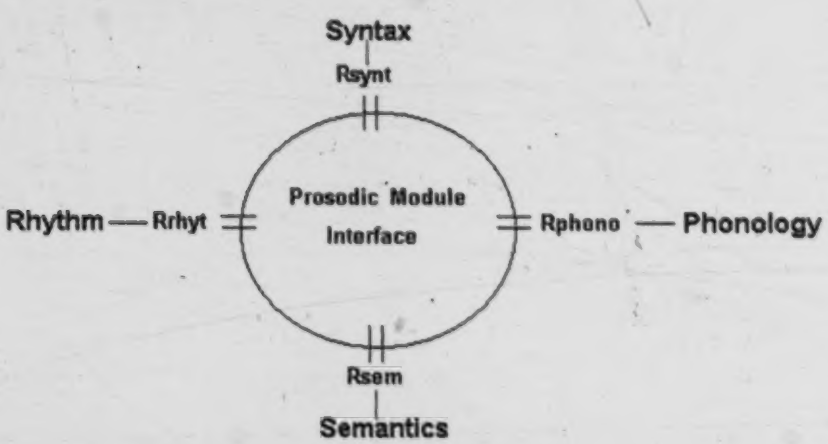


Figure 2-4 The Structure of Prosodic Grammar (Delais-Roussarie 1995:174)

In her account of French rhythm, Delais-Roussarie proposes constraints for the formation of stress groups, intonational groups, and for stress assignment. These constraints are based on her observations made on the analysis of two corpora of French. Based on these observations, the author proposes a first group of constraints for the formation of *stress groups*:

> (a) a syntactic alignment constraint (RYTHM), which assigns the right boundary of a stress group to the rightmost constituent of a syntactic group.

RYTHM: Align (RG, r; X', r)

where the right boundary (r) of a rhythmic group (RG) is aligned on the right boundary of a syntactic constituent (X').

(b) rhythmic constraint (MAX), which favors a balanced rhythm.

MAX: stress groups can not include more than six syllables

This last rhythmic constraint works in conjunction with another constraint which favors the formation of intonational groups of equal length (EQUI):

EQUI: within C^{i+1}, each prosodic constituent C^{i} has the same number of syllables.

According to the author, smaller constituents (C^{i}) are unlikely to display an identical number of syllables within a larger prosodic constituent (C^{i+1}). Thus, it is proposed that if the number of syllables is similar (± 1), the constraint is minimally violated.

These first three constraints are ranked according to the following hierarchy:

EQUI >> MAX >> RYTHM

For instance, a sentence like (27) would be segmented like the following:

(27) [Les jeunes enfants] $_{RG1}$ [regardent] $_{RG2}$ [le magnifique] $_{RG3}$ [rhinocéros] $_{RG4}$ [à la télé] $_{RG5}$

In (27), the rhythmic group ("le magnifique") is not aligned on the right boundary of an X' syntactic constituent. In doing so, it violates the constraint RYTHM. If it did, we would have had the sentence "le magnifique rhinoceros". where MAX would have been violated. This last violation is considered fatal.

The experimental section of her work led to a second group of constraints. These contribute to the well-formedness of **intonational groups**:

(a) Intonosyntactic alignment, which ensures that no syntactic group is spread over two intonational groups:

SPRO: Align (SPRO, r; X', r)

where the right boundary of the intonational group (SPRO) is aligned with the right boundary of the syntactic group (X')

(b) Intonosyntactic break between the NP subject and the VP, which stipulates that no intonational group will be carried over to the verb phrase:

RUPTURE: Align (SV, 1, SPRO, r)

where the right boundary of the first intonational group ends at the beginning of the verb phrase

(c) Rhythmic Balance, which favors the same number of syllables in each prosodic constituent (C) within one sentence:

EQUI: in a sequence of prosodic constituent C^i forming a larger prosodic constituent C^{i+1}, each C^i has the same number of syllables

(d) PROGRESSION, which is antagonist to the preceding constraints, in the sense that it favors an increasing number of syllables in a subsequent intonational group:

PROGRESSION: within a prosodic unit, the number of syllables increases regularly within a sentence.

The model proposes the following ranking for the last four constraints:

SPRO >> RUPTURE >> {EQUI, PROGRESSION}

The application of these constraints is illustrated in examples 28 and 29 below:

(28) [(Le gardien)] [(a vu) (le beau chien)] [(de ma voisine)]
(29) [(Le dernier fils) (du gardien)] [(a vu) (le beau chien) (de ma voisine)]

In these examples, the sequence *le beau chien de ma voisine* is segmented in one or two RG based on the size of the first prosodic constituent of the sentence.

The above ranking of constraints required for the formation of intonational groups highlights some important facts:

1. contrary to the formation of stress groups, syntactic factors are ranked higher than rhythmic factors,
2. some constraints are not in a strict dominance relationship --EQUI and PROGRESSION,
3. the formation of all rhythmic groups is based on the formation of the first one.

Delais-Roussarie also proposes a third set of constraints for **stress assignment**. The first two constraints determine the assignment of the *primary* stress and the last five determine the assignment of the *secondary* stress.

Primary stress will be assigned according to the following two constraints:

(g) METRICALHEAD$_{RG}$: .. σ σ σ] $_{RG}$ [4]

This first constraint stipulates that the last syllable of a group will be assigned primary stress (underlined in (g)) if it is not extrametrical (end in a mute "e"). In

[4] In this section, "σ" indicates a syllable, and ω indicates a phonemic word.

the option where it would be extrametrical, the second constraint would move the stress on the previous syllable within a phonemic word (ω):

EXTRAMETRICAL ... σ σ σ]$_{RG/\omega}$

|

N

|

ə

These first two constraints are ranked according to the following:

EXTRAMETRICAL >> METRICALHEAD

These first two constraints for the assignment of stress are completed by another series of five constraints which regulate the assignment of secondary stresses:

-GRAM: monosyllabic functional words do not bear stress

-* CLASH: two adjacent syllables can not be accented

-NOLAPSE: no more than two unaccented syllables are allowed

These constraints are ranked according to the following:

{GRAM, * CLASH} >> NOLAPSE

One more constraint is required to account for stress assignment on a phonological word:

HEAD$_{\omega}$: ... σ σ σ]$_{\omega}$

All constraints on stress assignment in French are ranked according to the following order:

EXTRAMETRIQUE >> METRICALHEAD >> {GRAM, * CLASH} >> {$HEAD_{\omega}$, NOLAPSE}

The final stage of the analysis represents the integration of the different inputs from all independent modules and the selection of the proper output. It is hypothesized that the rhythmic module specifies the weight of each syllable (strong or weak). The syntactic structure of the sentence, in the form of a tree, is also made available for evaluation. The assessment of the candidates from the three independent modules is done in parallel by the central module called H-Eval. Candidates which violate the higher ranked constraints will be rejected and the one which violates the lowest constraints will be chosen.

This model constitutes a comprehensive attempt to explain the mechanism of French prosody. The modular approach chosen under this framework allows for the complex integration of three seemingly independent sources of information, namely syntactic, semantic, phonological and rhythmic as illustrated in Figure 2.4. This integration also offers a valuable tool for the generation of synthesized speech.

While this approach represents an interesting model for the creation of rhythmic groups and for the explanation of the prosodic structure of French, it remains unsatisfactorily on a number of points. First of all, the assumption of a specific rhythmic module included in the prosodic grammar, even though interesting, requires better support. The necessity of having a separate module for rhythmic properties of French but not for other properties like intonational variations is not clear. The integration of the information coming from all independent modules has also been questioned. It has been proposed that the processing of the information could be rendered more effective by a

hierarchical structure instead of a parallel one (Lacheret-Dujour & Beaugendre 1999:158). In addition, the list of constraints proposed by Delais-Roussarie is based mostly on the empirical investigation on a restricted corpus presented in the first part of the dissertation. One could ask how much these constraints might change if further instrumental analyses were to be performed, or if they were to be performed on different corpora. Thus, the model would benefit from additional analyses done on different types of corpora in order to account for dialectal variations, as well as speaking styles.

2.2.3 Summary

This review of the most important accounts of French rhythm highlights the complicated nature of the phenomenon under study. The complexity of the models presented also demonstrates that a proper prediction of stress assignment requires the interaction of several different constraints. The most recent models propose to integrate intonational, syntactic, and semantic properties of an utterance in order to provide a satisfactory rhythmic structure. However, more empirical validation is required to confirm the coherence of these models. In addition, the validity of these models must be assessed for different dialects and speaking styles. Even though the exact interaction between all factors involved is still unclear, there is little doubt that stress, in French as in any other language, serves primarily as an organizational tool, and that it provides an overall structure for the prosodic organization of speech.

2.3 Second Language Acquisition of Segmental Information

The research discussed so far suggests that the L2 acquisition of suprasegmental information like rhythm would be a fairly complicated and lengthy process. However, before a closer examination of these issues is presented, it is necessary to review the previous research concerning L2 acquisition of segmental information. This section presents an overview of the most important approaches and models which have been developed in order to

predict and explain the acquisition of new segmental oppositions. The most important theoretical points will also be highlighted and briefly discussed.

2.3.1 Contrastive Analysis

No doubt for as long as L2 instruction has existed, comparisons highlighting differences between the learner's L1 and target language sounds have been made. In fact, systematic contrastive descriptions of languages appeared as early as the end of the XIXth century from Sweet (1890), Viëtor (1890), and Sievers (1901) who used them to try and improve L2 pronunciation. This approach was formalized by researchers around the middle of the twentieth century, who called it Contrastive Analysis (CA).

According to CA studies, done mostly in the mid 1950s and 1960s, L2 pronunciation problems were a result of differences between the phonemic systems of the first and second languages. This approach was adopted by Weinreich (1953) in a study on language interference. In this influential book, he intended to predict the problems speakers of Romansch or Schwyzertütsch would encounter in learning the target language. The basic principle of his approach was to first look for differences or missing elements in both phonemic inventories. Then, he would identify which elements would be difficult to learn based on this comparison or which substitutions would be likely to occur. Although this approach provided some satisfactory results, it failed to explain many cases of interference. For instance, Rochet (1995:393) explains that the English voiceless interdental fricative [θ] is replaced either by the stop [t] for speakers of languages like Russian or the fricative [s] for French or Japanese speakers.

At the time, the lack of success of CA did not dissuade researchers working with this theory. Lado (1957), Fries (1945) and Banathy et al. (1966)

formulated what Wardhaugh (1970) called the 'strong' hypothesis of CA.[5] This hypothesis was supposed to lead researchers to predict phonemic difficulties learners would have in learning an L2. For example, Titone (1966) admits it can help in the elaboration of an explanation: "No doubt scientific comparison of the contrasting features of the native and foreign languages explains the often encountered troubles besetting the learner ..." (p. 152) from Ragusich (1977:10)

The impossibility of predicting difficulties in L2 language learning as stated by the strong hypothesis forced a reformulation of CA. An alternative position, called the weak version, was proposed by Wardhaugh (1970:126), where CA is seen as an explanation of L2 learners' difficulties instead of a tool which predicts these difficulties:

> The weak version requires of the linguist only that he uses the best linguistic knowledge available to him in order to account for observed difficulties in second language learning. (...) It starts with the evidence provided by linguistic interference and uses such evidence to explain similarities and differences between systems. (p. 126)

Researchers also challenged CA on more fundamental considerations. For instance, researchers like Whitman (1970) and Jackson (1971) claimed that CA lacked 'procedural objectivity' in predicting difficulties during the acquisition of an L2:

> Anyone who has done a contrastive analysis knows that the procedures followed are not always rigorous or objective. For this reason, most extant contrastive analyses have built into them various degrees of subjective or intuitive procedures. (Jackson 1971:205)

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[5] A clear formulation of this strong version is found in Banathy et al. (1966:37).

The unit of analysis used for such comparisons was either the phoneme or the distinctive feature, which are both abstract units common to the field of linguistics. However, such theoretical considerations have failed to provide satisfactory explanations of the interference phenomena, as Brière (1966) explains:

> While the theoretical considerations are extremely important, descriptions and predictions of difficulty based solely on theoretical analyses at the phonemic level will be inadequate. A more complete description of phonological categories, in terms of their specific articulatory features on the phonetic level, is necessary. (p.769)

The application of this framework to predict the difficulties associated with the acquisition of rhythmic properties of an L2 would be very challenging, to say the least. The most important problem is that the use of this framework requires a very clear description of the L1 and L2 systems. The previous sections have demonstrated that it is not possible at this point to provide a clear and accurate account of the rhythmic properties of English and French, nor is it possible for any language. In addition, it is impossible to rule out at this point the possibility that rhythmic systems of different languages may require a noticeably different account. Therefore, it would be very difficult to propose a credible set of predictions based on two different rhythmic accounts.

This first approach to the explanation of L2 acquisition difficulties, however unsatisfactory, provided valuable information and a good starting point for further research in this field.

2.3.2 Flege's Speech Learning Model

Unlike CA, subsequent work paid more attention to the nature of the detailed acoustic information available to learners. Flege and his colleagues

(Flege 1981, 1988, 1991, 1992a, b, 1995) proposed a model called the Speech Learning Model (SLM). This influential model is aimed primarily at explaining "how speech learning changes over the life span and to explain why 'earlier is better' as far as learning to pronounce a second language (L2) is concerned." (Flege 1995:233) However, it has also proven useful in predicting assimilation patterns of new segmental oppositions in L2 acquisition.

The version proposed by Flege (1995) includes 4 postulates and 7 hypotheses:

Postulates

P1 The mechanisms and processes used in learning the L1 sound system, including category formation, remain intact over the life span, and can be applied to L2 learning.

P2 Language-specific aspects of speech sounds are specified in long-term memory representations called *phonetic categories*.

P3 Phonetic categories established in childhood for L1 sounds evolve over the life span to reflect the properties of all L1 or L2 phones identified as a realization of each category.

P4 Bilinguals strive to maintain contrast between L1 and L2 phonetic categories, which exist in a common phonological space.

Hypotheses

H1 Sounds in the L1 and L2 are related perceptually to one another at a position-sensitive allophonic level, rather than at a more abstract phonemic level.

H2 A new phonetic category can be established for an L2 sound that differs phonetically from the closest L1 sound if bilinguals discern at least some of the phonetic differences between the L1 and L2 sounds.

H3 The greater the perceived phonetic dissimilarity between an L2 sound and the closest L1 sound, the more likely it is that phonetic differences between the sounds will be discerned.

H4 The likelihood of phonetic differences between L1 and L2 sounds, and between L2 sounds that are non-contrastive in the L1, being discerned decreases as AOL [age of learning] increases.

H5 Category formation for an L2 sound may be blocked by the mechanism of equivalence classification. When this happens, a single phonetic category will be used to process perceptually linked L1 and L2 sounds (diaphones). Eventually, the diaphones will resemble one another in production.

H6 The phonetic category established for L2 sounds by a bilingual may differ from a monolingual's if: 1) the bilingual's category is "deflected" away from an L1 category to maintain contrast

between categories in a common L1-L2 phonological space; or 2) the bilingual's representation is based on different features, or feature weights, than a monolingual's.

H7 The production of a sound eventually corresponds to the properties represented in its phonetic category representation.

It is important to note the greater attention paid in this model to the phonetic information carried by the speech signal. However, this approach does not proceed solely on the nature of the acoustic information. In fact, Flege points out that the level of organization he is referring to in his first hypothesis (the allophonic level) is still an abstract level, where allophones may vary according to many factors such as 'speaking rate, degree of stress, the talker's age and gender, and other factors like speaking style or clarity.' In addition, this model is particularly interesting because of its detailed postulates and the explicit set of hypotheses which can be tested experimentally.

One of the most important hypotheses for this model is H2, which predicts that "new" phonetic categories will be established for L2 sounds that differ perceptually from the closest L1 sounds. The definition of a new phonetic category is determined by H3, which stipulates that the more important the perceived difference between L2 and the closest L1 sound, the greater are the chances to have a new phonetic category established. As well, these new sounds in the target language will be free of interference from the L1 and will have greater chances to be produced accurately. This process of establishing a new category may however sometimes be blocked by what Flege calls 'equivalence classification' (H5), which links perceptually L2 sounds to their L1 closest counterpart. When this happens, L1 and L2 sounds are produced with the same acoustic characteristics. For example, the SLM predicts that English learners of French should produce the new vowel /y/ more easily than the /u/ or the /i/ for example. To the contrary, 'L2 sounds with a close yet acoustically different counterpart in L2' are considered by the L2 learner as 'similar' sounds. Flege (1988) provides the French and English /t/ as a good example of similar

sounds. These two symbols are transcribed by the same IPA symbol even though they have a different place of articulation (/t/ is dental in French and alveolar in English).

This model has found supporting empirical evidence in several papers which investigated the acquisition of non-native segmental oppositions. Among those papers, Flege (1987) offers a convincing account of the effect of L1 phonetic categories on the acquisition of L2 phones. This paper investigates the production of French and English /t/ and /u/ by native speakers of French and English L2 learners of French. The model predicts that the mechanism of equivalence classification will hinder adult learners' capability to produce "similar" L2 segments whereas "new" segments will be easier to acquire. Therefore, English L2 learners of French should produce the new French /y/ more accurately than the similar /u/ (/u/ in English is closer to a central phone, [ʉ], than the back rounded French [u]). Their results confirmed their hypothesis. Among the three groups of English L2 learners of French, which differed in their amount of experience in the target language, only the least experienced produced /y/ with acoustic characteristics frequencies significantly different from the French monolinguals. To the contrary, even the most experienced English learners of French produced the French /u/ in an English-like manner.

In addition, the author hypothesized that the phenomenon of equivalence classification would trigger bi-directional linguistic influence. Thus, the acquisition of a similar L2 sound would have consequences not only on the production of the L2 sound, but also on the L1 phones. In order to test this hypothesis, Flege measured the production of French and English /t/ by native speakers of French and English. Results show that native speakers of French L2 learners of English produced the French /t/ with longer VOT values (Voice Onset Time) values than that of the monolinguals. Similarly, the most

experienced native speakers of English L2 learners of French produced the English /t/ with VOT values which are intermediate to the French and English averages of monolinguals. According to the author, this evidence specifically supports the distinction between new and similar phones, and the proposal which specifies that new phones are easier to acquire (H2, H3). As well, it supports the existence of the mechanism of equivalence classification (H5). The model has been investigated further in several subsequent studies (Flege 1992a, b, 1993, 1995, Flege & Bohn, 1989 among others).

SLM is also the first model to consider the age of learning (AOL) a second language (as stipulated by H4) as an integral part of the acquisition process. The difficulties to learn a new set of phonemic oppositions in an L2 have been related in the past to the critical period hypothesis (Scovel 1969, Long 1990), usually explained by neurological maturation, and to motoric difficulties.

However, this hypothesis has been challenged on several theoretical accounts (see Archibald & Libben 1995 for a review). It is still unknown exactly what mechanism may in fact explain the loss of language acquisition abilities as the result of maturation. As well, the empirical evidence failed to identify exactly at what age the critical period ends. For instance, Flege, Munro, and MacKay (1995) investigated the acquisition of English by 240 native Italian speakers who arrived in Canada between the ages of 2 and 23 years. In a perceptual experiment, native speakers of English rated perceived degree of foreign accent from their production of five English sentences. Results show that a negative correlation between their age of arrival in Canada and the degree of foreign accent. As expected, the degree of perceived foreign accent decreased with the increase of age of arrival in Canada.

What is more interesting is the lack of a clear discontinuity in their results. Such a discontinuity would have indicated the presence of a specific

age after which the degree of foreign accent increases noticeably, thereby supporting the existence of a critical period. For all the above-mentioned reasons, Flege's model takes the more gradual approach that "fewer sounds in the L2 will be produced accurately as AOL increases (both in terms of the range of sounds and the proportion of bilinguals)." (Flege 1995:241)

Despite the progress made in the ability to predict assimilation of foreign sounds, the SLM has one important shortcoming. It remains unspecified how to measure cross-language acoustic distance between L2 and L1 sounds. So far, no research has been able to identify what the relevant acoustic characteristics are when listeners estimate phonetic distance. Such distance is subject to variations related to the context, the speaker, the situation, etc.

As Flege (1995:264) points out, Best (1995) proposes that speakers gauge phonetic distance in terms of 'difference of perceived gestures'. Although it remains to be determined if this proposition is correct, it seems that it is once more going to be difficult to measure exactly what listeners perceive and how they can determine the relative distance between sounds or classes of sounds. Similarly, it remains undetermined what is required for a sound to be perceived as new in the L2. As Rochet (1995) explains, three criteria can and have been used in determining the acoustic distance between two sounds: "1) a phonetic symbol criterion; 2) an acoustic similarity criterion; and 3) listeners' perceptual judgements on L1 and L2 sounds." (p.387)

The use of these criteria presents a number of important problems. Among them, Rochet notes the lack of information carried by phonetic symbols. He also explains that the choice of the symbol is biased by the analyst's L1 experience and background and, therefore, 'grossly inadequate'. The acoustic similarity criterion is also questioned by Rochet. It has been suggested that sounds that do not fall within L1 phonetic categories can be

considered new. However, languages with large consonant or vocalic inventories are not likely to have any uncommitted space. The listeners' perceptual judgements on L1 and L2 sounds are also misleading either because of their methodology or because of other factors like orthographic representation and visual information. He concludes by questioning the usefulness of the "new" category proposed by Flege:

> ... it seems quite likely that the conditions under which truly new L2 phonetic categories are encountered are very rare and that the notion of new L2 phone—where "new" means "not perceived as belonging to the same category as any of the existing L1 sounds"—is not a meaningful one. (Rochet 1995:392)

Rochet illustrates this claim with empirical evidence from an experiment conducted by Flege (1990). In this experiment, Flege investigates the perception of the "new" English sound /æ/ for Spanish speakers with three experimental techniques: "1) attribution of a perceived task to one or none of five L1 vowel phonemes; 2) a rhyming task; and 3) a triadic comparison test in which the subjects were required to "pick out" the odd one." Rochet (1995:392) The results obtained from Flege from these tasks all denied the existence of a new category for the English vowel /æ/ for Spanish speakers. These results, together with two more experiments described in Flege and Bohn (1989) support Rochet's claim concerning the existence of new categories. Since this discussion seriously challenges the existence of new sounds, the only remaining possibility is that L2 sounds will be perceived as "similar" which means that they will be perceived according to L1 categories. Therefore, it remains to be determined what is the process of interlingual identification for L2 speakers[6].

One final comment must be made regarding the SLM. The sixth hypothesis predicts that bilingual speakers may have phonetic categories that are significantly different from those of monolingual speakers. The situation in which phonetic categories are slightly shifted may occur because the speaker needs to maintain phonetic contrast between L1 and L2 categories or because the speaker uses different features (or a different order of the features, Repp 1983) to represent phonetic categories (Flege 1995:242). It is important to mention here that this hypothesis relies on the fourth postulate proposed by Flege, which stipulates that both L1 and L2 phonemic systems of bilingual speakers are considered to appear in the same phonological space. However, no experimental evidence in the scientific literature is available that supports this hypothesis.

The clear hypotheses proposed in the latest version of the model are particularly interesting for researchers who seek empirical validation involving instrumental analyses. Of particular interest for this study are hypotheses 2 and 3. These two hypotheses will be used to predict the establishment of a new rhythmic structure for French by English L2 learners, as explained in greater detail in section 5.1.

However imperfect the SLM may be, it still represents a serious attempt at explaining L2 speech learning. Some of its aspects could be refined, like the definition of allophonic level and the notion of new categories. A better methodology also needs to be provided in order to evaluate cross-language phonetic distance. Finally, further research could be done in order to investigate the relationship between L2 speech perception and production.

2.3.3 Best's Perceptual Assimilation Model

Best (1994, 1995) proposes an appealing account of speech perception also aimed at understanding in the broad sense the development of speech. It

[6] The reader can refer to Rochet (1995) for a more detailed discussion of this topic.

draws on theory borrowed from psychology to explain the nature of the information perceived in speech and how this influences the phonetic and phonological properties of the listener's language. As well, it provides an interesting account for the development of speech perception during L1 acquisition as well as for perceiving non-native speech.

The Perceptual Assimilation Model (PAM) finds its fundamental principles in James Gibson (1966, 1979) and Eleanor Gibson (1969, 1991), and their research in psychology. Their theory takes an ecological approach based on the direct realism philosophy. The central premise of this approach stipulates that perceived events are directly accessed by the perceiver without the use of any intermediate stage or device that would require inference from the real physical events.

When applied to speech perception research, this central premise stipulates that perceivers "perceive objects, surfaces, and events directly without mediation by inborn knowledge or acquired mental associations." The second interesting property of the PAM is that (contrary to the Motor Theory and the psychoacoustic accounts of speech perception for instance) there is no translation needed between perception and production. This direct relationship ensures that the child can produce the new patterns he has heard before:

> A major appeal of the ecological approach to speech development, therefore, is its assumption that perception and production share a common metric of information – the articulatory gestures of the human vocal tract. This perception-production link is crucial to the language-learning child, who must not only recognize the patterns of native words across diverse productions by widely different speakers but also to produce reasonable approximations of those patterns. By the ecological

account, no translation is needed between perception and production because they are informationally compatible. (Best 1994:180)

This information being shared in perception and production suggests that, as for the SLM, speakers will reproduce L2 speech sounds according to their perception of the same L2 sounds.

The fundamental hypothesis of the PAM for cross-language perception is based on gestural similarities between the native and non-native sounds. These non-native sounds will "tend to be perceived according to their similarities to, and differences from, the native segmental constellations that are in closest proximity to them in native phonological space." (Best 1995:193) Assimilation will take place if the discrepancies between the native and the non-native sounds are not large enough to trigger establishing a new sound. This magnitude of difference between the gestural properties of both L1 and L2 sounds will then determine to what degree non-native sounds will be assimilated. In best cases, a segment will be assimilated to a native category as a good exemplar of that category. In worst cases, the discrepancies will be so important that the non-native sounds will be heard as nonspeech sounds made by the vocal tract (e.g. choking). In describing all the possibilities, Best (1995) provides the following patterns of assimilation of non-native *segments*:

Non-native sounds will be:

a) assimilated to a native category either as:

- a good exemplar of that category
- an acceptable but not ideal exemplar of the category
- a notably deviant exemplar of the category

b) assimilated as uncategorizable speech sounds (it falls within native phonological space but between categories)

c) not assimilated to speech (considered as being a nonspeech sound)

As mentioned previously, there is no reliable methodology for determining cross-language distance, or 'gestural similarities'. The preceding discussion has illustrated that the use of the phonetic symbol, acoustic information, or the listeners' perceptual judgements are not without problems.

Assimilation of non-native *contrasts* in PAM is based on assimilation patterns of each member of the contrast. Discriminability of these new patterns is based on the type of assimilation:

Assimilation patterns	Assimilation of the non-native contrasts	Expected discriminability
a) Two-category (TC)	• each non-native segment is assimilated to a different native category	• excellent
b) Category-goodness difference (CG)	• both sounds are assimilated to the same native category • one is acceptable, one is "deviant" from the native sound	• moderate to very good, depending on the goodness of each of the non-native sounds
c) Single-category (SC)	• both sounds are assimilated to the same native category • both are equally discrepant from the native "ideal" sound	• poor
d) Both uncategorizable (UU)	• both sounds fall within phonetic space, but outside any native phonological category	• from poor to very good, depending on their proximity with native categories
e) Uncategorized versus categorized (UC)	• one non-native sound assimilated to a native category, one falls into phonetic space outside any native phonological category	• very good
f) Nonassimilated (NA)	• both non-native sounds are considered as being nonspeech sounds	• good to very good

Supporting evidence comes from several experiments involving adults' perception of non-native contrasts (see Best 1993, 1994a, 1994b for detailed explanations). For example, Best (1995) mentions that they have tested the

predictions of the model with American listeners' perception of several non-native vowel contrasts. They observed that three vowel contrasts (French rounded mid front versus central vowels; French oral/nasal back rounded vowels; Thai high versus mid back unrounded vowels) were assimilated according to four different patterns: TC, CG, UC or SC. No explanation is provided though as to why are some of the contrasts assimilated to one pattern instead of another. Such an explanation is possible only through a detailed phonetic description of the sounds involved based on the distribution of those sounds in each language (Kohler 1981, Brière 1966, Rochet 1995).

Best's model presents an interesting view of speech perception mainly because it draws on a theory of perception that has a wider scope. Such a theory has a greater chance to predict the assimilation of non-native speech sounds that will be coherent with the phenomenon of speech perception in general. However, this model requires some improvement especially regarding the explanation provided in order to predict the perception of foreign speech sounds.

2.3.4 The Phonetic Continuum

There is a third approach that has been proposed by a small number of researchers for predicting assimilation of new phonemic oppositions. This approach does not constitute a theory nor is it entirely new. However, it has the indisputable advantage of offering the best explanation of the phenomenon of segmental assimilation.

Contrary to the previous theories, Rochet (1995) proposes that faulty production of L2 sounds can best be predicted using the acoustic characteristics of the speech sounds involved. To him, faulty production of a target sound can at least be partially explained by miscategorization of this sound. For instance, he refers to the situation where speakers of a language whose vocalic inventory contains two high vowels have to learn to produce the

three high vowels of the target language. In many cases, speakers will find very difficult to produce all three vowels clearly and distinctively.

In order to test his hypothesis, he used 10 native speakers of standard French, 10 native speakers of Canadian English, and 10 native speakers of Brazilian Portuguese. Speakers of Canadian English are known for their substitution of the French [y] by the English [u] whereas speakers of Brazilian Portuguese tend to substitute [i] for the [y]. In an imitation task, speakers of both groups were capable of reproducing monosyllabic French words containing [y] in more than 50% of the cases. In fact, native speakers of French identified 52% and 51% of the words produced by Portuguese and English native speakers respectively as successful attempts. This indicates that an articulatory explanation cannot solely account for the faulty production of the French [y].

The perceptual experiment required speakers to identify synthetic stimuli as /i/ or /u/ (except French participants who had to identify the same continuum as /i/, /y/, or /u/). This experiment revealed that the crossover boundary for Portuguese speakers was considerably lower than for English speakers. This means that stimuli with acoustic properties falling around this boundary (typically around 1300 and 1900 Hz) could be perceived as /y/ by French speakers, as /u/ by English speakers and as /i/ by Portuguese speakers. Therefore, in order for French learners to produce the three high vowels distinctively, they must acquire the ability to discriminate all three sounds in a native-like manner. A miscategorization by learners of the perceived sound will undoubtedly lead to its faulty production.

However, a proper account of assimilation of new phonetic categories cannot be explained solely by the physical attributes of the sounds involved. As demonstrated by Rochet and Putnam Rochet (1999), phonotactic constraints are also involved in the perception of new contrasts. They support their

argument with a psychoacoustic experiment which involved the perception of the same continuum involving European French /i/, /e/ and /ɛ/ in closed and open syllables. Results show that native speakers divide this continuum in two categories when presented in CVC context and in three categories in CV context. To the authors, these results explain why native speakers of French produce the English word "happy" with a final /e/ and "presented" with a /i/.

This type of approach, where more attention is spent on the physical attributes of the speech sounds under study, is not a novel idea. It was proposed for the first time more than 30 years ago (Brière 1966), and it has been endorsed by several researchers since (Kohler 1981, Rochet & Fei 1991). Its lack of popularity among the community of L2 researchers is most likely due to the absence of theoretical motivations and the difficulty of generalizing and predicting assimilation patterns without a detailed and sometimes meticulous analysis of the phonetic continuum. Despite these theoretical considerations, this approach is the most effective and deserves more consideration from researchers in this field.

The current research takes a similar position, in the sense that it considers that using the acoustic continuum is the most appropriate approach to describe the acquisition of L2 rhythm. In addition, the complexity of the topic being investigated calls for an analysis which highlights the most salient properties of rhythm, which can only be provided through a detailed and systematic instrumental analysis.

2.3.5 Summary of L2 Acquisition Approaches

The models described above are essential to the explanation of the phenomenon of foreign accent. They provide interesting frameworks for the prediction of assimilation patterns of non-native speech sounds, and offer valuable experimental evidence for the explanation of speech perception. Of particular interest for this study is the importance given to the influence of the

mother tongue in the acquisition of new phonemic contrasts. It is also worthy of mention that the most coherent explanations rely on acoustic descriptions of the speech continuum in both the L1 and L2. However, none of them has addressed the question of the acquisition of suprasegmental characteristics of an L2.

2.4 Second Language Acquisition of Suprasegmental Information

2.4.1 The Importance of Suprasegmentals In L2 Speech

Few studies published in the field of L2 acquisition have investigated the acquisition of suprasegmental factors. This fact seems in contradiction to the importance that faulty prosody may have in the production of L2 learners, both as a source of unintelligibility and a cause of dysfluency. The current section will review the most relevant studies in this field.

The importance of L1 suprasegmental over segmental errors in an L2 has been investigated in several studies (Morley 1991, Pennington & Richards 1986). Johansson (1978), for example, measured the relative effect of faulty suprasegmentals and segmentals on native speakers' subjective judgement of foreign accent. British English judges were asked to rate speech samples of Swedish ESL learners. Judges were presented extended text passages, individual words, and sentences read by native speakers of Swedish. The author hypothesized that rhythm and intonation are more apparent at the discourse level than at the level of isolated words and sentences. According to this hypothesis, lower ratings should be given to the extended text than to the sentences or the words. This is exactly the effect that was revealed in his study.

Another interesting study is Munro (1995). His goal was to quantify the effect of faulty suprasegmentals on perceived foreign accent. In his experiment, he asked 10 native speakers of Mandarin and 10 native speakers

of English to describe in English the events that were presented to them in a series of cartoons. This speech was then rendered unintelligible through low-pass filtering with cut-off frequencies of 225 Hz and 300 Hz for male and female speakers respectively. This procedure removed most of the segmental information without altering the suprasegmental information. Then these utterances were presented to 20 untrained native speakers of English, who were asked to rank them according to their degree of perceived foreign accent.

Results showed higher ranking for native speakers of English than for native speakers of Mandarin. These results suggest that there is sufficient information in filtered speech to identify foreign accent. Many other studies have reached a similar conclusion, for example Munro and Derwing (1995), Anderson-Hsieh (1992), and van Els and de Bot (1987), thereby supporting the alleged influence of suprasegmental properties in the perception of foreign accent.

The importance of suprasegmental errors in an L2 is also supported by several studies that demonstrated the influence of the intonational features of L1 in an L2. For example, Grover, Jamieson, and Dobrovolsky (1987) measured intonation curves of speakers of French, German, and English. Their analyses showed that contrary to the expectations, native speakers of English in Canada enrolled in French immersion displayed English intonational patterns. Despite several years of instruction in their L2, students' continuative intonation slopes move from a French native-like pattern in the target language at age 10 to a more English-like pattern by age 16.

The difficulty of learning melodic patterns of an L2 has also been established by Lepetit (1989). In this study, the production of 25 French sentences by 45 native speakers of Canadian English and 30 native speakers of Japanese was examined. Analyses of the melodic curve revealed no effect of French experience among native speakers of English. This suggests that

during their first three years of formal instruction at university, students had not improved noticeably their intonational patterns in French. Similar results were found for native speakers of Japanese. The author considers that cross-linguistic influence is responsible for the production of faulty intonational contours in French. Similar errors from Japanese learners have also been noticed by Lepetit, who proposes that the narrower variations exhibited by these learners suggests an influence of the Japanese phonetic characteristics rather than its phonological rules. Lepetit also reports faulty intonational contours by Japanese learners of French in Kojima (1977) and Anan (1980). The effect of an 'intonational foreign accent' has also been measured in Gibson (1998). In her study, Gibson demonstrated that some native speakers of Russian learning English as an L2 displayed some difficulty to associate specific intonational curves in English with their emotional significance.

One could hypothesize that the persistence of L1 intonational contours in L2 acquisition is caused by a loss of sensitivity to prosodic variations that are not part of our native language prosodic system, in a process similar to the selective loss of sensitivity to our non-native segmental variations. There is experimental evidence which shows that untrained listeners are sensitive to differences in cross-dialectal and cross-linguistic prosodic patterns (Bush 1967, Ohala & Gilbert 1981, Willems 1982). In fact, Barkat, et al. (1999) have demonstrated that prosodic patterns are reliable enough to discriminate even between two dialects of Arabic.

The empirical evidence reviewed emphasizes the importance of prosodic factors in L2 speech. However, there are some serious methodological issues that need to be addressed. The most important problem relates to the difficulty for listeners in determining the importance of suprasegmental errors compared to segmental errors (Munro 1995:19). A simple count of segmental versus suprasegmental errors does not provide a satisfactory account of the relative importance of these errors. More

significantly, it is still unresolved what constitutes a segmental or suprasegmental error. For example, how much tolerance should be allowed to vowel formants before they are counted as a mistake?

Moreover, separating the suprasegmental features of speech from segmental features is nearly impossible. Even an experimental technique used in a recent experiment, low-pass filtering (Munro 1995), does not completely remove the segmental information, since it still leaves the temporal characteristics of the segments. Munro (1995), for instance, notices very explicitly that the filtering technique used in his experiment, even though it constitutes a significant improvement on other techniques used previously, did not remove completely all segmental information. In the light of so many methodological complications, it becomes clear that more research a number of different investigative techniques and on a range of languages will have to be compiled before it is known with any real accuracy what is the effect of faulty prosody in L2 speech.

2.4.2 The Acquisition of L2 Rhythm

In one of the rare studies on the acquisition of L2 rhythm, Wenk (1985) investigated the existence of intermediate stages of acquisition. The theoretical foundations are drawn from a previous study Wenk and Wioland (1982) which gave rise to a new typological distinction between languages based on their rhythmic properties. The empirical evidence reported on in Wenk and Wioland shows that French syllables within a rhythmic group, far from being identical in duration, are characterized by a gradual increase in duration which reaches a peak on the final syllable. The authors claim that this tendency is the opposite to the one exhibited in English, where the initial syllable of a foot is regularly marked acoustically. This fundamental distinction between the two languages, and others associated with different phonemic properties of the two languages, led to the coining of the terms leader-timed and trailing-timed for English and French respectively.

For Wenk (1985), this central distinction between the rhythmic properties of English and French represented an excellent opportunity to investigate cross-linguistic influence in L2 acquisition. In this study, the author tried to determine if native speakers of French would exhibit intermediate stages in the acquisition of English rhythm. These stages, according to the predictions made by the theoretical framework, would reflect the gradual increase of the rhythmic unit.

In order to measure this phenomenon, native speakers of English evaluated French intermediate learners' pronunciation in the target language. Learners' proper pronunciation was based on their ability to reduce English unstressed vowels. In an imitative task, the 43 learners who participated in the experiment properly reduced 40% of the pre-tonic vowels and 81% of the post-tonic ones. The author explains that learners acquire a transitional rhythmic grouping intermediate to the L1 and L2 system that makes them produce tense pre-tonic and lax post-tonic vowels.

The presence of a faulty temporal structure in an L2 has been confirmed by Freland-Ricard (1996). In her study, she tested the claim that L2 learners do not acquire the prosodic system of the target language without specific instruction. In order to do so, she analyzed the temporal structure of one sentence in French produced by speakers with a different first language (Denmark, Netherlands, Sweden, United States, Norway, Spain, and Germany). All learners were characterized as having a good knowledge of French. Her measurements revealed that French learners do not produce primary stress in a similar fashion to native speakers. Some learners displayed different temporal modulations to mark primary stress and some learners did not mark primary stress at all.

This study also documented different temporal patterns for speakers with a different first language. This led the author to claim that the first language has an effect on the acquisition of the prosodic system of the target language. There is another relevant study that has shown that L1 durational properties are persistent in an L2. Bila and Zimmermann (1999) measured vowel durations of Slovak speakers of English in an attempt to verify the acquisition of English rhythm. For the researchers, the explanation lies in the durational differences between the stressed and unstressed vowels in both languages. Slovak stressed syllables are in average 1.2 times longer than unstressed ones, and in English stressed vowels are 1.5 times longer than unstressed ones. They claim that learners do not maximize the durational contrast between these two types of vowels. These last two studies suggest that duration is a salient property of French and English rhythm. In addition, the acquisition of the proper temporal rhythmic structure of an L2 appears to be challenging for L2 learners. As will be shown in the current research, the importance of this parameter will be confirmed.

2.4.3 Summary

The relatively low number of studies reviewed in the previous section contrasts with the vast literature available on the acquisition of new segmental oppositions in an L2. There is, however, enough evidence to suggest that the influence of L1 suprasegmental features on an L2 is very important in the subjective judgement of foreign accent by native speakers. In addition, the empirical evidence reviewed suggest that L1 suprasegmental features, such as intonation, tend to persist in an L2, even in immersion. In the acquisition of English, Wenk has found that native speakers of French acquire the rhythmic structure of the target language gradually, via transitional rhythmic groupings. In Bila and Zimmermann (1999), acoustic measurements have revealed that the lengthening of stressed syllables in a target language can be influenced by the learner's L1. Together, this empirical evidence indicates a clear influence of L1 suprasegmental structure on L2. In addition, this strongly argues in favor of

additional research this field in order to fully comprehend the effect of L1 on the acquisition of an L2.

2.5 Summary of the Literature Review

This literature review has four main sections. In the first one, an overview of the research on the nature of speech rhythm was provided. The first part presented the difficulties associated with the task of offering a satisfactory definition for the broad and complex notion of *rhythm*. Many researchers have felt that this notion, rather than being restricted to the use of language, constitutes an inherent part of human activity. Thus, a proper definition should reflect the multifaceted character of this phenomenon. When defined for a specific field of study (poetry, linguistics, etc.), however, the definitions did not require such a broad scope and were considered more satisfactory. For instance, many linguists would agree that speech rhythm can be defined as "the perceived regularity of prominent units in speech." (Crystal 1991) This definition must be completed with a special emphasis on the central properties of linguistic rhythm, namely *structure* and *time*.

The second part offered a summary of the debate on the nature of speech rhythm. The traditional typological account of rhythm classifies languages in one of three categories: stress-timed, syllable-timed, and moraic. Instrumental investigations have failed to support this strict classification and most authors now consider these labels as tendencies rather than categories. Further studies on the nature of speech rhythm led to the proposal that the two opposing rhythmic types be replaced by a continuum with prototypical stress-timed and syllable-timed languages located at opposite ends. Other languages would be located on this continuum according to their approximate resemblance to either type. Recent investigations (Ramus et al. 1999) support the hypothesis that timing properties of languages are better accounted for by the phonemic properties of a specific language. Additional support for this

proposal comes from empirical evidence which suggests that rhythm varies according to speaking styles (Astésano 1999) and dialects (Deterding 2000).

French rhythm, originally considered as a prototypical example of a syllable-timed language, is now considered the result of two opposing tendencies: a tendency to produce syllables of equal duration, and a tendency to produce stress groups of equal length. Its role in the delimitation of syntactic units was recognized early during the investigations. Many researchers also consider stress placement as central to the rhythmic structure of French. The central role of primary stress in the determination of the rhythm of a language has convinced researchers to explore stress assignment based on the syntactic structure of the utterances (Martin 1980, 1986, 1987), in conjunction with intonational variations (Hirst & Di Cristo 1993, 1996), or as a component of a separate module which contributes to the overall prosodic structure of an utterance (Delais-Roussarie 1995). The most recent models share the common feature of considering that the rhythmic properties of French are a combination of several factors: syntactic, semantic, and intonational.

In the third section of this literature review, an overview of the main findings regarding the acquisition of new L2 segmental oppositions was provided. This section also attempted to present the most important problems related to the study of the complex phenomenon of rhythm. Research in L2 acquisition led to the development of comprehensive accounts of the acquisition of new segmental oppositions, namely the SLM (Flege 1995) and the PAM (Best 1995). The frameworks proposed by these models allow researchers to make valuable predictions regarding the acquisition of new segmental oppositions in a coherent manner with the development of speech perception abilities. However, the empirical evidence appears to support an approach which rests on the acoustic descriptions of the phonetic continuum rather than on theoretical constructs (Rochet 1995, among others). Such

models and approaches, however, have yet to address the acquisition of suprasegmental properties of an L2.

Finally, the fourth section presented a review of studies which have investigated the acquisition of suprasegmental properties of an L2. The empirical evidence presented has brought to light the importance of prosody in the acquisition process, and strongly argues in favor of the extension of these investigations.

3. DATA COLLECTION

3.0 Introduction

This chapter describes the procedure for collecting the corpus and the data used for the analyses presented in Chapters 5 and 6. In addition, parts of the corpus were used for the perceptual experiment presented in Chapter 4.

In order to investigate the acquisition of the rhythmic properties of French by English L2 learners, a corpus of speech material was collected. This corpus involved the pronunciation of a series of controlled sentences (Recall corpus, see section 3.3.1) and of an unstructured interview (Free Speech, see section 3.3.1) done with the main experimenter. Both recordings were produced in French by English L2 learners and native speakers of French. Measurements of syllabic duration variability will be taken on the Recall corpus in order to determine if learners of French exhibit more variability than native speakers. The Free Speech corpus will be used to determine if the analysis of the laboratory corpus can be generalized to free speech. The following section explains the details of the procedure and briefly discusses some methodological issues.

3.1 Participants

A total of 12 subjects agreed to participate in this experiment. All subjects filled out a background questionnaire (see Appendix A4 and A5) prior to the experiment in order to provide background information on their social and linguistic characteristics. The questionnaire was available in both English and French and participants were presented with the form in their mother tongue. The twelve participants were paid $15.00 upon completion of the tasks.

The participants in this experiment included 6 English L2 learners of French and 6 native speakers of French who were recruited from the student and staff populations at the University of Alberta. The group of English participants was further divided into 2 subgroups, according to their oral proficiency in French (subjectively evaluated by the experimenter during the interview) and the number of years of contact they had with French: 3 were low intermediate learners (VR, CK, AL), and 3 were advanced learners (AK, CW, KB). Among these English participants, 5 were native speakers of Western Canadian English (VR, CK, AL, CW, KB), and one of American English from the Boston area (AK). The low-intermediate participants, VR, CK, and AL, reported they had started learning French between the age of 8 and 14 years. They all had between 7 and 13 years of exposure to formal instruction in high school or university. Participants AK, CW, and KB, the advanced participants, reported learning French mostly in a naturalistic environment. In fact, they reported extensive immersion periods in French-speaking environments, either in Montreal or in Paris. One speaker, AK, reported speaking almost exclusively French at home with his wife who is a native speaker of Canadian French.

All native speakers of English reported speaking at least one second language in addition to French which, in most cases, belonged to the Germanic or Romance language families. Detailed descriptive information about these speakers is presented in Table 3.1. Low-intermediate and advanced participants have been called EL1 and EL2 respectively.

	EL1			EL2		
	VR	**CK**	**AL**	**AK**	**CW**	**KB**
L1	English	English	English	English	English	English
Age group	18-25	18-25	18-25	36+	36+	36+
Sex	F	F	F	M	M	M
Age started learning French	10	8	14	26	13	15
Years of formal instruction on French	7 years	13 years	8 years	0 years	13 years (High School, University)	6 weeks
Immersion or Time in a French Environment	None	5 weeks (Québec)	10 months (France)	7 years (at home)	15 months	13 years
Other languages spoken	Italian	none	none	Spanish Dutch German Papiamentu	none	German Spanish
Origin	Alberta (Canada)	Alberta (Canada)	Alberta (Canada)	Boston (USA)	Western Canada	Alberta (Canada)

Table 3-1 Social and linguistic characteristics of English L2 learners of French.

Native speakers of French were subdivided into two smaller groups, based on their dialect: 3 native speakers of Canadian French (CF), 3 native speakers of European French (EF)[7]. The native speakers of EF spoke what seemed to the experimenter to be a standard variety of French without noticeable traces of a regional accent. In contrast, the speakers of CF used a less formal variety of French during the interviews, which included a number of features usually considered non-standard[8] but which are widespread in this dialect. All three speakers of EF had come to Canada for professional reasons and had been in this country for a few months only, except for JD who had been here for 3 years prior to the experiment. They used French mostly in their professional activities and their contacts with the regional French community

[7] European French is considered as a standard variety of French, and would be similar to that spoken by a large number of people in a major city of northern France, like Paris. This variety has no noticeable trace of any specific regional accent as perceived by the experimenter. It is not however limited to the dialectal area of the Parisian dialect. It is contrasted to a standard variety of Canadian French.

were relatively limited. A more complete description of the characteristics of native speakers of French is presented in Table 3.2.

	CF			EF		
	AG	**HV**	**VB**	**VE**	**JD**	**MC**
L1	CF	CF	CF	EF	EF	EF
Age Group	18-25	18-25	18-25	18-25	26-30	18-25
Sex	F	F	F	F	M	F
Childhood Language	French	French	French	French Creole	French	French
Country of Origin	Québec (Canada)	Québec (Canada)	Québec (Canada)	La Réunion	Paris (France)	France
Other Languages Spoken	English Spanish German	English	English	English	English	English
Time in an English Environment	Few months	Few months	Few months	4-6 months	3 years	4-6 months

Table 3-2 Social and linguistic characteristics of native speakers of French.

3.2 Material

Recordings for this experiment were made on a Teac RW-800 compact disk deck. A Shure SM10A headset microphone was plugged into a dbx 760x microphone preamplifier and into a Lucid Technology ADA 1000 A/D-D/A Converter. The sampling rate chosen on the converter was 44.1 kHz. All recordings and interviews were done in a sound-treated room in the Department of Linguistics at the University of Alberta.

The relevant sound files were transferred to a personal computer for the acoustic analysis. The system called Computer Speech Laboratory (CSL) model 4300 made by Kay Elemetrics was used for digitization and measurements. Speech samples were digitized with a sampling rate of 20 kHz.

[6] Features like vowel lengthening, diphthongization, fronting of /ã/, the opening of /ɛ/ to /a/, etc. (Walker 1984, Paradis and Dolbec 1992).

3.3 Procedure

3.3.1 Tasks

Two types of speech samples were collected from all 12 participants. The first sample consisted of recalled single-sentence utterances (Recall); the second was a 30 to 45 minute interview with the experimenter (Free Speech). The interviews were conducted by the author of this research who is a native speaker of CF. All speakers performed both tasks in French during the first session. Native speakers of English were recalled a few months later to perform a recall task similar to the first session, but with English stimuli. This second set of data was used in the analysis to compare syllable duration variability in the production of native speakers of English and native speakers of French.

For the recording of the Recall corpus, participants were presented with a single sentence on a computer screen. They were instructed to read the sentence out loud once, hit a key that would bring a blank page on the screen and then repeat the sentence from memory. They were allowed to proceed at their own pace using the keyboard to display the following sentence. In case of misreading or any other mishap during the recording–coughing, memory failure, etc.–speakers were instructed to produce the sentence twice again, as if it were the next sentence. Due to the relatively high number of sentences to be uttered, no distractors were used. Participants were instructed to read and repeat the sentences "as naturally as possible". The second utterance of every sentence was used for measurements. All speakers read the same list of sentences presented in random order. This type of elicitation was considered more natural than a reading task, where participants are highly influenced by the stimuli, while allowing for the use of a structured and controlled set of stimuli.

The second part of the recording, called Free speech, involved an unstructured conversation between the interviewer and the participant. This interview lasted about 30 minutes and covered a wide range of topics. These topics included participants' past and future trips, some hypothetical plans if they won the lottery, a discussion about siblings, children, pets, etc. The speech material collected in this second part of the interview will be used to verify if the syllabic duration variability found in the Recall corpus can be generalized to free speech.

3.3.2 Stimuli

The stimuli for the Recall task were single sentences which included one rhythmic group varying in length. Sentences were constructed so that it would be possible to increase the size of the rhythmic group under study by the addition of unstressed syllables while keeping the rest of the sentence similar. It was expected that a corpus in French with such a structure would allow for proper investigation of the acquisition of the timing pattern of French rhythm. English L2 learners of French were expected to display more variability in syllabic duration than native speakers of French.

In this corpus, the first word of each sentence, a proper noun, and the last syllable of the verb were considered highly likely to be stressed, hence forming the left and right boundaries respectively of a rhythmic group. This is illustrated in sentence 1.5, "[*Luc* **qui au-rait** man*gé*] se serait endormi.", where *Luc* and *-gé* are expected to bear primary stress. Half of the rhythmic groups measured in the Recall corpus included a relative clause which was gradually expanded with unstressed syllables. Each relative clause had between 1 and 4 unstressed syllables as illustrated in sentences 1.1 to 1.5 below:

Stimulus Number	Stimuli
1.1	[*Luc mange*] beaucoup.
1.2	[*Luc* **qui** *mange*] beaucoup est très mince.
1.3	[*Luc* **a man-***gé*] et s'est endormi.
1.4	[*Luc* **qui a man-***gé*] s'est endormi.
1.5	[*Luc* **qui au-rait man-***gé*] se serait endormi.

In this example, the stressed syllables are in italic characters, and the additional unstressed syllables are in bold characters. The second half of the rhythmic groups contained a verb phrase which was also gradually expanded with the addition of unstressed syllables, as illustrated in the following example:

Stimulus Number	Stimuli
3.1	[*Claude voit*] Marie à la fenêtre.
3.2	[*Claude* **a** *vu*] Marie à la fenêtre.
3.3	[*Claude* **n'a pas** *vu*] Marie à la fenêtre.
3.4	[*Claude* **n'au-rait pas** *vu*] Marie à la fenêtre.
3.5	[*Claude* **ne l'au-rait pas** *vu*] à la fenêtre.

Six sentence groups each containing the same basic vocabulary were conceived. Some of these sentences had to be slightly modified in order to ensure grammaticality. The modifications required replacing of lexical items (e.g., *mange* became *mangé* in sentence-group 1). Table 3-3 lists all French stimuli.

Sent. Group*	Stimuli (French)	English translations (not used in recording)
1.1 [0]	[*Luc mange*] beaucoup.	*'Luc eats a lot.'*
1.2 [1]	[*Luc* **qui** *mange*] beaucoup est très mince.	*'Luc who eats a lot is very thin.'*
1.3 [2]	[*Luc* **a man-***gé*] et s'est endormi.	*'Luc ate and fell asleep.'*
1.4 [3]	[*Luc* **qui a man-***gé*] s'est endormi.	*'Luc who ate fell asleep.'*
1.5 [4]	[*Luc* **qui au-rait man-***gé*] se serait endormi.	*'Luc who would have eaten would have fallen asleep.'*
2.1 [0]	[*Pierre peint*] très bien.	*'Peter paints very well.'*
2.2 [1]	[*Pierre* **qui** *peint*] travaille beaucoup.	*'Peter who paints works a lot.'*
2.3 [2]	[*Pierre* **qui a** *peint*] travaille beaucoup.	*'Peter who painted works a lot.'*
2.4 [3]	[*Pierre* **qui nous a** *peint*] travaille beaucoup.	*'Peter who painted us works a lot.'*
2.5 [4]	[*Pierre* **qui nous a bien** *peint*] travaille beaucoup.	*'Peter who painted us well works a lot.'*
3.1 [0]	[*Claude voit*] Marie à la fenêtre.	*'Claude sees Mary at the window.'*
3.2 [1]	[*Claude* **a** *vu*] Marie à la fenêtre.	*'Claude saw Mary at the window.'*
3.3 [2]	[*Claude* **n'a pas** *vu*] Marie à la fenêtre.	*'Claude did not see Mary at the window.'*
3.4 [3]	[*Claude* **n'au-rait pas** *vu*] Marie à la fenêtre.	*'Claude would not have seen Mary at the window.'*
3.5 [4]	[*Claude* **ne l'au-rait pas** *vu*] à la fenêtre.	*'Claude would not have seen her at the window.'*
4.1 [0]	[*Paul aime*] la chasse.	*'Paul likes hunting.'*
4.2 [1]	[*Paul* **ai-***mait*] la chasse.	*'Paul liked hunting.'*
4.3 [2]	[*Paul* **a ai-***mé*] la chasse.	*'Paul liked hunting.'*
4.4 [3]	[*Paul* **a-vait ai-***mé*] la chasse.	*'Paul has liked hunting.'*
4.5 [4]	[*Paul* **a-vait bien ai-***mé*] la chasse.	*'Paul has liked hunting a lot.'*
5.1 [0]	[*Rome brûle*].	*'Rome burns.'*
5.2 [1]	[*Rome* **qui** *brûle*] sera détruite.	*'Rome which is burning will be destroyed.'*
5.3 [2]	[*Rome* **qui bru-***lait*] sera détruite.	*'Rome which was burning will be destroyed.'*
5.4 [3]	[*Rome* **qui a brû-***lé*] serait détruite.	*'Rome which burnt would be destroyed.'*
5.5 [4]	[*Rome* **qui au-rait brû-***lé*] serait détruite.	*'Rome which would have burnt would be destroyed.'*
6.1 [0]	[*Jean boit*] le vin.	*'John drinks the wine.'*
6.2 [1]	[*Jean* **a** *bu*] le vin.	*'John drank the wine.'*
6.3 [2]	[*Jean* **a-vait** *bu*] le vin.	*'John drank the wine.'*
6.4 [3]	[*Jean* **au-rait pu** *boire*] le vin.	*'John could have drunk the wine.'*
6.5 [4]	[*Jean* **n'au-rait pas pu** *boire*] le vin.	*'John would not have been able to drink the wine.'*

Table 3-3 French stimuli for the Recall corpus. Words or syllables in italic are the ones which are expected to bear the primary stress mark. The measured phrase structures are inside square brackets.

*** This column indicates the sentence group (1-6) and sentence stimuli (1-5), and the number of unstressed syllables in the measured phrase structure in square brackets (0-4).**

In total, 360 sentences were included in the Recall corpus (30 sentences x 12 participants). The main analysis involved measuring the

duration of each syllable within the rhythmic group. These measurements will then be used to calculate the amount of inter-syllabic variability for all groups of speakers. The different methodologies used in each analysis are explained in detail before each result section, in Chapter 5 and 6.

In the Free speech corpus, a total of 74 sentences were analyzed. Contrary to the Recall corpus, the speech material chosen in the analysis of this corpus did not depend on the syntactic structure. Rather, it was decided to select uninterrupted sentences of at least 10 syllables. Such longer sentences would provide a more representative sample of free speech. The choice of the speech material for this analysis is explained in greater detail in Chapter 5 (section 5.2.4).

3.4 Syllabification

Segmentation of the French Recall and Free speech corpora into syllables was done according to the principles explained by Delattre (1940, 1944a, 1944b) and verified experimentally by Beaudoin (1996). The following is a summary of the rules proposed by Delattre and presented in Beaudoin (1996:33) in order to syllabify intervocalic consonants:

- a single intervocalic consonant is syllabified as the onset of the second syllable (e.g. 'n'au.rait' /nɔ.rɛ/), leaving the first one without a coda (open syllable);
- for a consonant cluster (-rp-, -bl-, -sp-, -cr-, etc.), preference is given for splitting the cluster. However, some clusters are not split according to the following rules:
  - a cluster is kept together if the sonority of the first consonant is clearly lower than that of the second consonant (-sp-, -st-, -pr-, etc.);

- if the first consonant is pronounced in the front of the mouth and the second one further back (-pt-, -lr-, -mn-, etc), the cluster will tend to stay together, provided that the previous rule is respected.

Following the previous rules, intervocalic consonants which correspond to the phenomenon of *liaison*[9], were assigned to the following or the preceding syllable, in accordance with the sonority hierarchy[10] (Treiman & Zukowski 1990, Delattre 1940). For instance, the final [t] in *avait*, in the sentence "*Paul avait aimé la chasse.*" may be pronounced because the following syllable starts with a vowel. Thus, it was assigned to the following syllable. The same [t], if followed by a syllable starting with a consonant, as in "*Paul avait bien aimé la chasse.*", would not be uttered by native speakers of French. Similarly, intervocalic consonants which correspond to the phenomenon of *enchaînement*, were reassigned to the following syllable.

As well, the importance of the prosodic boundary was taken into consideration in the segmentation process. Thus, final consonants which correspond to the *enchaînement* were not reassigned to the next syllable across a major prosodic boundary[11]. Liaison consonants would not have been uttered across these boundaries. Major prosodic boundaries are frequently found between major syntactic constituents. For instance, a potential liaison between an NP in subject position and the following VP would not be allowed, as in "[Le petit]$_{NP}$ [aimait bien la tarte aux pommes.]$_{VP}$" with no liaison between the underlined segments.

During the segmentation, it appeared necessary to add one rule to be able to syllabify the speech of English L2 learners. Some instances of a glottal

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[9] Definitions of *liaison* and *enchaînement* can be found in Encrevé (1988).
[10] The sonority hierarchy in increasing order, as described by Delattre (1940, cited in Beaudoin 1996), is as follows :
stops → nasals → fricatives → liquids → glides
[11] See Léon (1992).

stop have been found in the corpus. These stops were considered like the other stops and were assigned to the following syllable, according to the following rule:

- Glottal stops (produced by English speakers) were treated as a consonant and considered the onset of the next syllable.
  e.g., "j'ai une fille" [ʒ e ʔ y n f i j] would be syllabified [ʒ e . ʔ y n . f i j].

The syllabification of the free speech presented additional problems. For instance, native speakers of French frequently drop the "e muets" during a conversation. Therefore, the remaining consonants, left without a nucleus, were assigned to the preceding or the following syllable, according to the sonority hierarchy and to the rules from Beaudoin (1996). For instance, "Je le prends" and "...vient de finir..." would be syllabified /ʒ ə l . p r ɑ̃/ and /v j ɛ̃ . d f i . n i r/ respectively.

An exception to the rules had to be made for the sequence of a fricative and a stop, as in "Je pourrais..." pronounced /ʃ p u r ɛ/. The application of the sonority hierarchy would require that, after the "e" has been dropped, a syllable boundary be inserted between the consonants /ʒ/ and /p/, which would leave the first syllable without a nucleus. In this case, to avoid having a syllable formed by a single consonant, both consonants were considered part of the onset of the same syllable: /ʃ p u . r ɛ/.

3.5 Measurements of Syllable Durations

The analyses of both the Recall and Free speech corpora involved taking measurements of syllable durations in the phrase structures described above. These measurements were used to compute the variability index in the analysis described in Chapter 5 (section 5.1.4). All measurements were taken

on the waveform of the digitized speech signal with the help of the spectrograms displayed in a separate window on the monitor. Each syllable was measured from the onset of the first segment (consonant or vowel) to the onset of the first segment of the next syllable. The point of measurement was the first positive value after the zero-crossing point on the window displaying a waveform (100 ms of the signal was displayed each time). The infrequent silent and filled pauses found in both corpora were not excluded from the measurements of syllable durations.

Some problems arose during the measuring process. When decisions were made arbitrarily, it was decided that all subjects be given the same treatment under similar circumstances. For instance, the Recall corpus had sentences with a stop ([k] or [p]) in sentence-initial position. Since it was impossible to determine the onset of the stop, it was arbitrarily decided to add 100 ms to the duration of the stop. This value was chosen after measuring several stops in word-initial but not in sentence-initial position of some of the speakers. This same value was used for all speakers. Some sentences also presented cases of consonantal or vowel assimilation. In sentence 1.2 (*Luc qui mange beaucoup est très mince.*), for instance, there is a sequence of two velar stops. In such a case, speakers merged the two consonants into one, producing only one phase of closure followed and a single burst. It was arbitrarily decided to segment half way between the onset of the stop and the first cycle of the next segment (a vowel in this case), splitting the consonants in two segments of identical duration. Thus, the following rule was added to the ones previously stated:

- adjacent assimilated vowels and consonants were segmented half way in two segments of identical duration[12];

[12] Vocalic segments were divided into three phases: an *onset*, where the vowel exhibits irregular wavelength and with insufficient amplitude, a *steady* portion, where the signal is formed by a regular wavelength with sufficient amplitude, and an *offset*, which is characterized by a decrease in amplitude or an irregular wavelength.

3.6 The English Corpus

In order to compare the production of native speakers of English in both English and French, a second corpus was gathered. The methodology adopted for the recording of this second corpus was identical to the one used Recall corpus in French. There was, however, no free speech in English collected during this second interview. The same native speakers of English who recorded the French corpus were contacted again and asked to participate in a second recording session. The stimuli used for this session were short sentences matched in the number of syllables, syntactic structure, and, in some cases, the syllable structures with those in the French corpus. The list of all sentences used in this recording is given in the following:

Sent. Group*	Sentences
1.1 [0]	[*Luke longs*] for Sue.
1.2 [1]	[*Luke* **who** *longs*] for Sue is too tense.
1.3 [2]	[*Luke* **has been** *gone*] and has not been seen.
1.4 [3]	[*Luke* **who has been** *gone*] has not been seen.
1.5 [4]	[*Luke* **who would have been** *gone*] would have been seen.
2.1 [0]	[*Claire paints*] quite well.
2.2 [1]	[*Claire* **who** *paints*] travels a lot.
2.3 [2]	[*Claire* **who has** *paint*ed] travels a lot.
2.4 [3]	[*Claire* **who should have** *paint*ed] travels a lot.
2.5 [4]	[*Claire* **who should have been** *paint*ing] works a lot.
3.1 [0]	[*Jim saw*] Mary at the window.
3.2 [1]	[*Jim* **has** *seen*] Mary at the window.
3.3 [2]	[*Jim* **has not** *seen*] Mary at the window.
3.4 [3]	[*Jim* **would not have** *seen*] Mary at the window.
3.5 [4]	[*Jim***my would not have** *seen*] Mary at the window.
4.1 [0]	[*Paul likes*] to hunt.
4.2 [1]	[*Paul* **would** *like*] to hunt.
4.3 [2]	[*Paul* **would have** *liked*] to hunt.
4.4 [3]	[*Paul* **would not have** *liked*] to hunt.
4.5 [4]	[*Paul***a would not have** *liked*] to hunt.
5.1 [0]	[*Rome burns*].
5.2 [1]	[*Rome* **which** *burns*] will be destroyed.
5.3 [2]	[*Rome* **which was** *burnt*] will be destroyed.
5.4 [3]	[*Rome* **which has been** *burn*-]ing will be destroyed.
5.5 [4]	[*Rome* **which would have been** *burn*-]ing would have been destroyed.
6.1 [0] **	[*John drinks*] the wine.
6.2 [1]	[*John* **has** *drunk*] the wine.
6.3 [2]	[*John* **has been** *drink*-]ing.
6.4 [3]	[*John* **would have been** *drink*-]ing.
6.5 [4]	[*John* **would not have been** *drink*-]ing.

Table 3-4 English stimuli for Experiment #1. Words or syllables in italic are the ones which are expected to bear stress mark.

*** This column indicates the sentence group (1-6) and sentence stimuli (1-5), and the number of unstressed syllables in the measured phrase structure in square brackets (0-4).**

**** Because of experimental mishaps during the recording phase, sentences in group 6 (6.1-6.5), although recorded, do not form part of the analyses.**

The segments of interest in these materials, like in the French Recall corpus, were syllabified and the syllable durations measured in order to determine the timing patterns in English.

3.6.1 Syllabification of English Utterances

Rules of syllabification in English are not agreed upon by all researchers. The proper assignment of intervocalic consonants is far from being clear and an argument can be made for assigning these consonants in the same bisyllabic word either in coda position of the first syllable, or in onset position of the second syllable.

It is not necessary in the current dissertation to debate any further the possibilities of syllabifying English words. The nature of the English words used in this corpus reduces the number of possible ambiguities. As well, the experimental task limited the coarticulation phenomena. For instance, there was no instance of syllabic consonants found in the corpus. Contrary to the French corpus, no free speech was used in the analyses. Thus, the syllabification was done according to the following principles:

- there will be one syllable for each vowel,
- morpheme boundaries will be considered as syllable boundaries,
- intervocalic consonants will be syllabified according to the Maximal Onset Principle,
- ambiguous consonants will be assigned to the onset of the next syllable.

In sum, the analysis presented in this research will investigate the rhythmic properties of speech material gathered in the following corpora:

a) Recall corpus in French: structured stimuli recorded with 12 speakers. These participants included 3 low-intermediate (EL1) and 3 advanced (EL2) English L2 learners of French, 3 native speakers of CF, and 3 native speakers of EF);

b) Free speech in French: unstructured interviews recorded with the same 6 English L2 learners of French and 3 native speakers of CF as in the previous corpus;
c) Recall corpus in English: structured stimuli recorded with the same 3 low-intermediate (EL1), 3 advanced (EL2) English L2 learners of French, and 3 native speakers of CF.

The Recall corpus will provide comparable speech material in French and English, thereby allowing the determination of the opposed rhythmic tendencies displayed by native speakers of these two languages. The determination of these tendencies will involve the computation of a global index which accounts for variations in syllable duration. Variations in duration are considered the most salient property of French and English rhythm.

In addition, the production of speech material of identical syntactic structure in French by all groups of speakers (native speakers of English and native speakers of French) will allow an accurate comparison of the temporal rhythmic structure in French as produced by speakers differing in their proficiency. It is reasonable to expect that more proficient speakers will be able to approximate the temporal structure of French with better success than less proficient speakers. Speech excerpts from the Free speech corpus will be used in the analysis to see if the variations in syllable duration measured in the Recall corpus in French are similar to variations found in unrestricted speech material (section 5.3.4).

Finally, the alleged dialectal differences in the rhythmic structure of Canadian and European French will be examined through the analysis of speech excerpts from the Recall and Free Speech corpora.

4. LEVEL OF PROFICIENCY OF ENGLISH L2 LEARNERS OF FRENCH

4.0 Introduction

This chapter presents the results of a perceptual experiment using the corpora described in Chapter 3. In order to reach the overall goal of this research, which is to measure the acquisition of prosodic features in L2 acquisition, it is necessary to evaluate the proficiency of English L2 learners in French. The purpose of this chapter, then, is to outline the procedures used to accomplish this preliminary task. This included a perceptual experiment, called Experiment I, which was designed to objectively asses the native speakers of English with respect to their L2 ability. Once assessed, speakers were then categorized as either Intermediate or Advanced.

The categorization of each speaker was based on three different assessments.

- The results of a preliminary questionnaire.
- The assessment of the primary experimenter.
- Rankings provided by 12 native speakers of French.

As mentioned in Chapter 3, participants were given a questionnaire before the first recording session. In this questionnaire, participants had to indicate their age, when they started to learn French, how many years of formal education they had and how much exposure to French they had. Each subject also underwent a 30 minute interview with the primary experimenter during the main recording session. After this, the experimenter indicated which group the subject belonged to.

Finally, in order to confirm that these assessments were not biased, a perceptual experiment was devised where native speakers were instructed to classify the 12 speakers according to their perceived level of proficiency in

French. The results of this experiment touch on three issues. These are: a) will speakers be classified in distinct categories? b) will the six native speakers of English be classified in two distinct categories of equal size, and all native speakers of French classified as such, and c) what will be the degree of consistency among judges on the ranking of all participants.

4.1 Methodology

4.1.1 Judges

The judges who assessed the native speakers of English were 10 native speakers of French who participated as volunteers in the experiment. Nine out the 10 judges were students in various disciplines at the Faculté Saint-Jean (University of Alberta) and the last one was a faculty member. They all reported having French as their first language and the majority reported having English as a second language. A minority of them had learned another language before they learned English.

The judges ranked the twelve participants (6 English learners of French, 6 native speakers of French) who had recorded the corpora described in Chapter 3. The linguistic and social background of the English L2 learners of French has been briefly described in Chapter 3. To recapitulate briefly, there were two groups of three native speakers of English each who differed in the amount of experience they had had in French. The less experienced learners of French (EL1) had between 7 and 13 years of exposure to formal instruction in French in high school or university. The more experienced learners of French (EL2) had, in general, spent extensive immersion periods in French-speaking communities either in Montreal or in Paris. All native speakers of English but one, the Bostonian, were native speakers of Canadian English. Native speakers of French were subdivided in two groups, based on their dialect: 3 native speakers of Canadian French (CF), 3 native speakers of European French (EF).

4.1.2 Procedure

This experiment took place at the Faculté Saint-Jean (University of Alberta). The judges were asked to listen to three excerpts for each of the twelve speakers who participated in this study. A web page was setup where judges could click on the excerpts in *.wav* format using their computer mouse. Speakers were randomly presented on the web page and judges could listen to the excerpts as often as they wished. The judges were instructed to score the speakers according to their level of proficiency. They were also told that the experiment included L2 learners and native speakers of French. All instructions and documents presented to the judges were in French (see appendix A1).

Evaluation was done on a seven-point scale presented on paper. The scale on the questionnaire had three levels of proficiency called *Débutant* (beginner), *Intermédiaire* (intermediate), and *Avancé* (advanced) and went from 1 to 7, with 1 being the lowest level of proficiency and 7 being the highest. Levels 1 and 2 corresponded to *Débutant*, 3 and 4 to *Intermédiaire*, and 5 and 6 to *Avancé*. The last point on the scale, 7, corresponded to the proficiency of a native speaker of French. The lower number of each level of proficiency corresponded to a lower proficiency than the higher one. For instance, a speaker considered a beginner and ranked as "1" would be less proficient than another beginner who was assigned a "2". There were no definitions nor examples given to illustrate the meaning of the categories. Judges were told in advanced that they were going to evaluate the proficiency of speakers who would either be learners or native speakers of French. In total, judges took between ten and fifteen minutes to complete the task.

4.1.3 Stimuli

The stimuli for this experiment were excerpts from the free speech interviews which were recorded during the second phase of the main recording session of this research. The stimuli for this perceptual experiment were three

sentences chosen from each interview. These sentences had to satisfy the following criteria:

- they included at least 10 syllables,
- they had very few pauses if any,
- they were produced with relatively few interruptions,
- they lasted no more than approximately 8 seconds, and
- they were judged by the researcher as representative of the speaker's speech during the interview.

Appendix A2 lists all sentences which were used for this perceptual experiment. No sentences were chosen from the first five minutes of an interview in order to ensure speakers' production would be more natural than in the first moments of the interview.

4.1.4 Material

The computer used in this perceptual experiment was a MacIntosh G4 400 MHz and an Operating System 9.1 with 320 Mo of RAM. The browser used during the experiment was Internet Explorer 5. The headphones were Sennheiser HD 435 Manhattan which were connected directly to the computer. All judges used the same computer and setup to complete the task.

4.1.5 Expected Results

Given the linguistic characteristics of all speakers, it was expected that English L2 learners of French would be ranked in two distinct classes. The first class would include the three speakers who were originally classified as low-intermediate (ranking of 3 or 4 on the proficiency scale for this experiment) by the experimenter. These speakers have, in general, a noticeably smaller amount of experience in French. The second group of learners was expected to include the three speakers who were initially classified as Advanced (ranking 5 or 6). These learners are more experienced and, in general, noticeably more proficient in French. Native speakers of French were expected to be ranked as

such (ranking of 7 on the scale) with no regard to dialectal differences between them.

4.2 Results

The initial classification, based on the information provided in the language-background questionnaire and on the experimenter's judgement during the interview, assigned participants in the following categories:

Low-Intermediate learners of French as an L2 (EL1)	Advanced learners of French as an L2 (EL2)	Native speakers of French (CF and EF)	
VR	CW	AG	MC
AL	AK	HV	JD
CK	KB	VE	VB

Figure 4-1 Initial classification of all participants

A preliminary analysis of the responses from the perceptual experiment revealed that those given by one of the judges was not consistent with the rest of them. In fact, it seemed as if this judge misinterpreted the instructions and gave a random pattern of responses. Therefore, the responses from this judge were excluded from the analysis.

Overall, the remaining results confirmed the initial classification of the speakers by the experimenter. The English L2 learners of French were classified in two relatively distinct categories. The three less experienced learners, VR, AL, and CK, received average scores of 1.6, 3.3, and 4.4 respectively. The relatively wide range of ranking is explained by the fact that judges were using their personal definitions of all three levels proposed on the grid as well as their personal points of reference. The low ranking assigned to VR (1.6) properly reflects this participant's rank as the least experienced speaker.

Advanced speakers were ranked noticeably higher than the first category with average rankings of 3.9, 4.9, and 5.8 for CW, AK, and KB respectively. The difference between these scores and the ones assigned to the EL1 participants justifies a distinct category. In comparison with the scores assigned to CW, AK, and KB, the average ranking of 4.4 assigned to CK in the previous group raises the possibility of assigning this participant to the Advanced category. However, it was decided not to do so after considering the fact that CK was assigned a relatively low (below the boundary of 4 which divides beginners and advanced subjects) ranking of 3 by three of the nine judges. It may have been the case that some judges focused on CK's relatively accurate pronunciation and did not consider CK's lack of knowledge in syntax or morphology. Similarly, CW received a ranking of 3.9, which was low enough to assign CW to the Intermediate category. CW's overall proficiency was evaluated by the experimenter as advanced during the 30 minute interview, based on CW's overall performance. All native speakers of French were assigned a perfect score of 7 by the judges.

The amount of agreement between judges in the ranking of all twelve participants was evaluated by using an intraclass correlation (Shrout 1995, Shrout & Fleiss 1979). In the specific ANOVA computed for this analysis, the factors *Judges* and *Participant* were declared *fixed* and *random* respectively. The two-way ANOVA was computed using SPSS version 10.0. The detailed results of the computation are shown in Appendix A3, and discussed below.

When most of observed variance is caused by variation among targets, there is high agreement between judges and the intraclass correlation (ICC) is high. The ICC for all nine judges was high at 0.895. A similar correlation was computed including the answers provided by the judge who appeared to have misunderstood the instructions. With this tenth judge, the rate went down to 0.711. The importance of this drop in the correlation argues in favor of the elimination of this judge.

	Speakers	Categories							Total	Average
		Beg.		Int.		Adv.		NS		
		1	2	3	4	5	6	7		
EL1	VR	5	3	1	0	0	0	0	9	1.6
	AL	0	1	4	4	0	0	0	9	3.3
	CK	0	0	3	0	5	1	0	9	4.4
EL2	CW	0	0	2	6	1	0	0	9	3.9
	AK	0	0	1	2	3	3	0	9	4.9
	KB	0	0	0	1	3	2	3	9	5.8
CF	AG	0	0	0	0	0	0	9	9	7.0
	HV	0	0	0	0	0	0	9	9	7.0
	VE	0	0	0	0	0	0	9	9	7.0
EF	MC	0	0	0	0	0	0	9	9	7.0
	JD	0	0	0	0	0	0	9	9	7.0
	VB	0	0	0	0	0	0	9	9	7.0

Table 4-1 Ranking of all speakers by all judges.

Table 4-1 shows the number of times a speaker has been ranked in each category during this perceptual experiment.

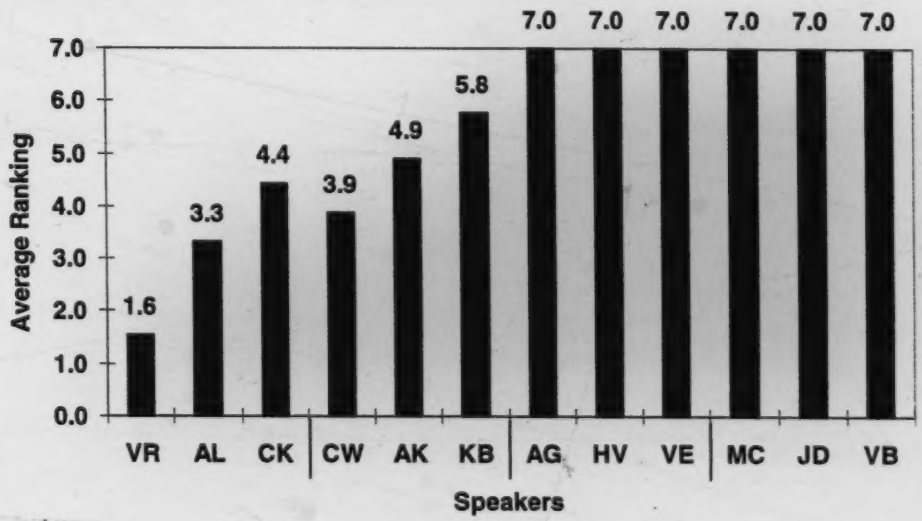

Figure 4-4-2 Average ranking by speaker.

4.3 Discussion

The goal of this experiment was to confirm the experimenters initial assessment of the twelve native speakers of English who would be participating in this study. The results show that the ranking done initially was consistent with the one provided by the nine judges who were native speakers of French. These judges ranked all participants as clearly belonging to one of three categories: two categories of learners of French and one category of native speakers. Speakers in the first category of learners typically had less exposure to French even though they had taken more language courses. Speakers who were judged as belonging to the second category had a limited number of formal instruction but had many years of exposure to the language in a social environment. When these factors are taken into consideration, it seems that these two categories could be called *Intermediate* and *Advanced*.

However, it is not required in this research to characterize with great accuracy the level of proficiency of speakers of each category. Therefore, these two categories of speakers will be referred to as EL1 (English native speakers as low-intermediate learners of French) and EL2 (English native speakers as advanced learners of French) respectively.

Even though the ranking was highly consistent among all judges, two of the learners could have been classified in a different category according to their ranking. For instance, CK received an overall ranking of 4.4, which could be compared the ranking EL2 speakers received. Similarly, CW's ranking of 3.9 could have placed him in the EL1 category. The difference between these rankings and the arbitrary boundary between our two categories of speakers (4 on the scale described previously) is very small. According to the initial classification, CK was expected to be assigned a ranking of 4 or less, and CW a ranking of 5 or more. It will be considered that these relatively small

discrepancies and their overall proficiency as judged by the main experimenter during the 30 minute interview support the initial classification. However, these discrepancies will not be ignored, as they may be used in the following analyses to explain individual differences within groups of speakers when necessary. This ranking would then locate CK at the high end of the continuum in the Intermediate category (EL1), and CW at the low end of the Advanced category (EL2).

It is unclear which criteria were used by the judges when ranking the native speakers of English. They may have relied on the overall fluency of the speaker, their accuracy in pronouncing individual segments, their knowledge of a more extensive lexicon, etc. Research at this point is unable to provide a satisfactory explanation for what precise factors are responsible for the perception of foreign accent. It is noteworthy, however, that CK spent 5 weeks in a French immersion program in the province of Québec. It is possible that she acquired some key features of the CF phonology during that period of time, which would have contributed to CK's higher ranking as an intermediate learner (Mougeon et al. to appear, Regan 1999). Similarly, CW has the shortest period of immersion among advanced learners. This may explain CW's ranking as the lowest of the advanced learners.

The third hypothesis concerning the consistency of the judges was also confirmed with a high agreement among judges. It would be extremely interesting to know exactly what the judges took into consideration in assessing the speakers' proficiency in French. This question, however, is very complex and can not be answered without a thorough investigation which is outside of the scope of this research.

5. ANALYSIS OF ENGLISH SPEAKERS' PRODUCTION IN FRENCH

5.0 Introduction

This chapter outlines the results and discussion related to the second of the three experiments done on the corpus gathered as described in Chapter 3. The goal of this experiment was to investigate the temporal rhythmic structure of English L2 learners of French in an attempt to determine if English learners acquire the temporal rhythmic properties of French. More specifically, this experiment will seek an answer to the following questions: (a) Is duration, as a primary property of the syllable, a proper account for the two main rhythmic types, namely stress-timed and syllable-timed? and (b) is inter-syllabic duration variability a suitable measure of learners' proficiency in French? As will be explained below, the results suggest that learners do, in fact, acquire the temporal rhythmic structure of French. The results also, then, support the claim that duration is a perceptually salient property of speech rhythm.

Since the first publications on speech rhythm, duration has been identified as a primary property of syllables allowing languages to be classified into two main categories (Jones 1960, Pike 1945, Abercrombie 1967). Despite the failure to find identical durations for all syllables in stress-timed languages, and identical inter-stress intervals in syllable-timed languages, recent studies have confirmed the importance of this parameter in the investigation of rhythmic properties. The measurement tools developed by Deterding (1994, 2001) and Ramus et al. (1999) have proven that languages can be differentiated based on their timing structure and that their classification corresponds to these traditional categories (Ramus et al. 1999).

As well, it has been shown that the timing properties of languages can be used to characterize Singapore compared to British English (Deterding 1994, 2001). This suggests that durational variations capture the overall

rhythmic structure of a language and can be used as a starting point for this investigation. The choice of duration as the primary parameter of investigation does not entail that rhythm is reduced solely to durational variations. In fact, there is empirical evidence which suggests that the rhythmic properties of a language are the result of a combination of acoustic cues which reflect the syntactic and phonemic properties of this specific language (Paradis & Deshaies 1991).

Among the postulates and hypotheses proposed under the SLM (see section 2.4.2 for a list of the postulates and hypotheses), H2 and H3 could be applied to the acquisition of an L2 rhythmic pattern. In summary, these two hypotheses predict that if L2 learners can perceive *phonetic differences* between the L2 and L1 sounds, they will establish new phonetic categories for the L2 sound. It is generally considered that there is no "category" per se in the rhythmic structure of an utterance. Therefore, it is hypothesized in this investigation that if L2 learners do perceive rhythmic differences between L1 and L2, they will establish a new rhythmic structure approaching the one displayed by native speakers of French. English and French have always been described as examples of stress-timed and syllable-timed languages respectively. Consequently, the phonetic contrast should be maximized between these two languages. Thus, the analyses presented in this chapter rest on the following assumptions: (a) native speakers of English will perceive phonetic differences between the rhythmic pattern of English and French, and (b) native speakers of English will establish a new rhythmic pattern when acquiring French.

The analyses presented in this chapter, which will be referred to as Experiment II, are the result of measurements done on the three corpora collected for this research: (a) Recall corpus in French, (b) Free Speech in French, and (c) Recall corpus in English (see Chapter 3 for details). The first analysis (section 5.2) describes the overall increases in duration in the

measured phrase structures in English and in French when unstressed syllables are inserted in the relevant structures (see section 3.3.2 for details on the stimuli). This analysis will help to validate the methodology used by allowing for comparisons with previous studies. The second main part of this chapter (section 5.3) will present the results of three analyses of the temporal rhythmic structure of both English and French. First, the amount of inter-syllabic variability displayed by each speaker group will be presented through the analysis of the production of French and English sentences collected in the Recall corpora (section 5.3.1 and 5.3.2). The tendencies for English L2 learners of French to display greater variability in French will be shown through the computation of an index based on local variations in duration. Second, a finer analysis will examine the possibility that the position of specific syllables in the measured phrase structures are related to a greater amount of inter-syllabic variability. A third analysis will compare the indexes of variability from the Recall corpus in French to indexes computed on sentences extracted from the Free Speech corpus in French.

In the last section, a summary of the most important results will be presented, followed by a discussion of their relevance for theories of L2 acquisition and for the account of linguistic rhythm. Additional issues and specific hypotheses will be briefly discussed before each analysis.

5.0.1 Experimental Hypotheses

The first hypothesis will be used to confirm previous descriptions of the rhythmic properties of English and French. In addition, three hypotheses will provide a direct answer to the experimental questions stated in the first paragraph of this chapter. In light of the studies mentioned above on the acquisition of new segmental oppositions in an L2, it seems reasonable to predict that English L2 learners of French will exhibit more inter-syllabic variability than native speakers of French. It also seems reasonable to expect

that this variability will decrease as their level of proficiency increases in French. Thus, the following hypotheses can be formulated:

a) native speakers of English will exhibit greater inter-syllabic variability in English than native speakers of French in French,
b) English L2 learners will exhibit greater inter-syllabic variability in French than native speakers of French in French,
c) English L2 learners of French will exhibit greater inter-syllabic variability in the earlier stages of acquisition than more proficient learners, and
d) both groups of native speakers of French will exhibit similar inter-syllabic variability.

5.0.2 Methodological considerations

The methodology used in gathering data for this experiment is explained in Chapter 3. In this section, the following methodological issues will be addressed: the account of variations in speech rate and the assessment of syllabic variability.

5.0.3 Normalization of syllable duration

One of the greatest problems with instrumental analyses of natural speech is that speakers are likely to display noticeable variations in their speech rate. These variations will also affect, among other factors, the duration of syllables and single segments. Therefore, in order to ensure that the analysis uses similar units across all speakers, it is necessary to normalize these variations in speech rate. In order to do so, the duration of each syllable was divided by the average duration of all the syllables in the measured phrase structures (Deterding 1994, 2001). The computation was done using this short formula:

NDUR = MD / AVGD
where:
NDUR = normalized duration,
MD = measured duration, and
AVGD = average duration of all non-final syllables in the rhythmic group.

These normalized durations will be used in assessing the amount of variability displayed by all groups of speakers. This assessment will be done through an index called VarIndex. The next section will describe in detail the nature of this index.

5.0.4 Accounting for syllabic durational variability

Variations in syllable duration will be evaluated with an index called the Variability Index (VarIndex). This index, identical to the one used by Deterding (1994, 2001) and similar to the one used in Low (1998), offers an overall account of rhythmic tendencies based on syllabic duration. Two reasons led us to choose this particular tool in assessing variability in syllabic duration. The first reason, as pointed out by Deterding (2001), is that it provides an assessment of syllable duration based on the duration of the neighbouring syllables. The use of neighbouring syllables in computing this index takes into account local variations in speech rate. It would have been possible to compare the duration of each syllable to the average duration of the entire sentence. However, in the case of a sentence with a noticeable change in speech rate, the deviations from this average duration would have been high, even for someone who displayed a strong tendency to produce syllable-timed speech. Therefore, the use of an index based on variations in duration from surrounding syllables allows for a more accurate assessment of variability. The second reason for choosing this index was the fact that it has been used reliably in previous studies, not only by Deterding in the above-mentioned references but also by Low (1998), with some minor adjustments. These adjustments were the exclusion of the final syllable, the normalization procedure and the procedure regarding the measurements of syllable durations. These three points are discussed below. The formula used in computing this index in the current study is shown below:

$$VarIndex = \left(\sum_{k=1}^{n-2} |d_{k-1} - d_k| \right) / (n-1)$$

where:
d_k = normalized duration of the k^{th} syllable, and
n = number of syllables

In the computation of this index, perfect syllable isochrony would allow for no durational variability, hence leading to a VarIndex of 0. The greater the variability in syllable duration, the greater the index is from zero.

Final syllables of the measured phrase structures were excluded from the computations of the VarIndex. The main motivation for doing so was the desire to evaluate solely the amount of variability of syllable duration while minimizing the influence of other factors. In our study, final syllables of every measured phrase structure (which should correspond to one rhythmic group) in French should bear primary stress. As discussed previously, primary stress is marked in French mainly by a noticeable increase in syllable duration. This noticeable increase may have a significant impact on the computation of the index by assigning the penultimate syllable a large value. Since English L2 learners of French may produce increases associated with this primary stress of different magnitudes than native speakers, additional variability will be introduced in the overall VarIndex. This effect, however, will be briefly analyzed at the end of this chapter. Needless to say, a more in-depth analysis of the production of primary and secondary stress by English learners would be required, but it is beyond the scope of this research. Table 5-1 illustrates how the VarIndex would be calculated using the normalized duration for the relative clause in the sentence "Pierre **qui nous a bien peint** travaille beaucoup" as produced by speaker VR (EL1):

Syllables	Duration	Normalized Duration	Difference from next syllable
Pierre	0.4400		
qui	0.2703	0.8107*	0.3164**
nous	0.3758	1.1271	0.6289
(z) a †	0.1661	0.4982	0.4886
bien	0.3290	0.9867	
peint	0.4194		
Average:	*0.3334*		
VarIndex:			**0.4780*** **

Table 5-1 Example of computation of the VarIndex.

*** The normalized duration is computed by dividing the duration of this syllable by the average duration: 0.2703/0.3334=0.8107.**
**** This difference is calculated by subtracting the value of the next syllable: 1.1271-0.8107=0.3164.**
***** This figure is the result of the average of all values in the last column.**
† Resyllabification of this type, caused by the *liaison*, has been taken into account during the measurements of syllable duration.

Proper computation of the VarIndex relies on the accurate location of syllable boundaries. The reader can refer to Chapter 3 for a more detailed discussion of this issue.

5.1 Descriptive Analysis

The measurements presented in this section are the durations of the measured phrase structures. The results include the measurements done on 25 sentences produced by all 6 native speakers of English for the English corpus, and the measurements of 30 sentences produced by 12 participants for the French corpus[13]. Examples (1) to (6) illustrate the measurements taken on both the English and the French corpora. Measured syllables are underlined.

[13] As mentioned in Chapter 3, minor experimental problems prevented for proper recording of the last group of sentences in the English corpus. Therefore, they had to be excluded from the analysis.

• French corpus:

(1) *Luc mange beaucoup. (RG1)*

(2) *Luc qui mange beaucoup est très mince. (RG2)*

(3) *Luc a man-gé et s'est endormi. (RG3)*

etc.

• English corpus:

(4) *Luke longs for Sue. (RG1)*

(5) *Luke who longs for Sue is gone. (RG2)*

(6) *Luke has been gone and has not been seen. (RG3)*

etc.

This section describes the overall tendencies observed in this corpus based on the unaltered total durations of the rhythmic groups as well as the relative duration of the additional syllables. As discussed previously, the dichotomy between stress-timed and syllable-timed languages implies that languages in the former category will exhibit similar inter-stress intervals, and that languages which belong to the latter category will display a similar increase in duration for each additional syllable. It is a widely held view that, even though no language will show perfectly identical inter-stress intervals nor identical syllable duration, these tendencies clearly differentiate languages like English and French. Therefore, an overall examination of the unaltered duration of this corpus should confirm a tendency in English to regularize the duration of the inter-stress intervals and to compress syllables. As well, it should demonstrate the existence of the tendency in French to regularize the duration of the additional syllables.

Since the first goal of this experiment is to measure the production in French of the rhythmic pattern of English L2 learners of French, the speech material was not specifically designed to investigate the tendency for English to exhibit isochronous inter-stress intervals. Instead, what will be examined is the

main consequence of stress-timed isochrony, namely the irregularity in syllable duration. This irregularity should affect additional unstressed syllables in the measured phrase structures. Therefore, it is expected that additional syllables in the measured phrase structures of our corpus of English will exhibit more variability in duration. Conversely, syllable-timed languages like French will display near-constant increases in duration with each additional syllable. In addition, as the greater proficiency scores assigned to more proficient learners of French in the previous experiment suggest, EL2 speakers should exhibit tendencies relatively close to the ones displayed by native speakers of French. Therefore, the results of this descriptive analysis should show the following tendencies:

a) native speakers of English should exhibit an irregular increase in the duration of the rhythmic groups with each additional syllable in English,
b) in contrast, native speakers of French should exhibit a similar increase in the duration of the rhythmic groups with each additional syllable in French,
c) in French, EL1 speakers should exhibit a slight decrease in the duration of rhythmic groups with each additional syllable (thereby showing a tendency to move closer to a French-like rhythmic pattern),
d) in French, EL2 speakers should exhibit a similar tendency to native speakers of French regarding the increase in the duration of rhythmic groups with each additional syllable (thereby showing acquisition of a French-like rhythmic pattern).

Individual variations will be examined in section 5.3 and following.

5.1.1 Results of the descriptive analysis

Table 5-2 and Figure 5-1 present the unaltered durations of the measured phrase structures on the English and French corpora. The

similarities between all the groups of speakers are more striking than their differences. Contrary to what was expected, the curves of the English, CF, and EF groups are almost parallel. The more gentle slope of the English speakers' production in English indicates that the increase in duration is lower than the one found in French. The speaker groups, EL2, CF, and EF are also very close to each other and indicate a similar increase between all three groups. The largest discrepancy between all curves is the one associated with the productions of EL1 speakers. This curve is indicative of a greater increase in duration with each additional syllable. In addition, the location of this curve on the y axis indicates that the first syllable was longer than for the other speaker groups. Individual differences will be assessed in a more detailed statistical analysis in section 5.3 below.

Rhythmic Group	EL1 (s)	EL2 (s)	CF (s)	EF (s)	ENGLISH (s)
RG1	0.3977	0.2868	0.2678	0.2517	0.3964
RG2	0.5194	0.4044	0.3775	0.3563	0.5037
RG3	0.7101	0.5813	0.5422	0.4778	0.6630
RG4	1.0243	0.7686	0.7003	0.6285	0.7800
RG5	1.3284	0.9783	0.8896	0.7931	0.9627

Table 5-2 Total and unaltered duration of Rhythmic Group for all groups of speakers: EL1 (English learners 1), EL2 (English learners 2), CF (Canadian French), and EF (European French).

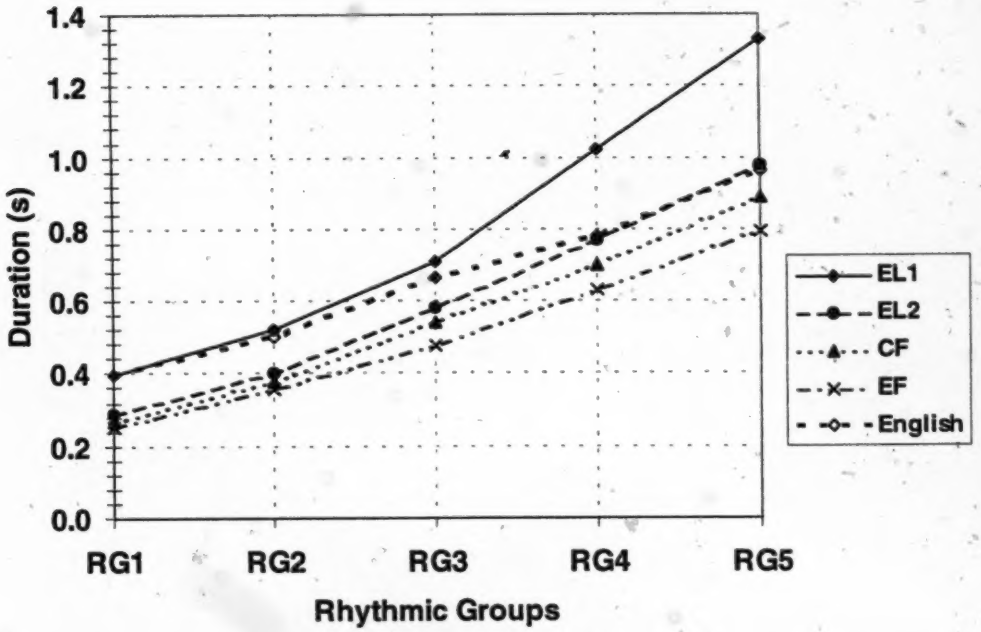

Figure 5-1 Total and unaltered duration of Rhythmic Groups for all groups of speakers: EL1 (English learners 1), EL2 (English learners 2), CF (Canadian French), and EF (European French).

5.1.2 Discussion

According to the widely spread distinction between rhythmic types, stress-timed and syllable-timed languages should have provided two distinct tendencies: a tendency to produce an equal and constant increase in duration with each additional syllable in French, and a tendency to provide irregular increases in order to satisfy the durational requirements between stress beats in English. The data presented above suggest a similar tendency for all groups of speakers to increase the size of the rhythmic group by a constant duration for each additional syllable. There is one exception to this rule however. Less experienced English L2 learners of French produced an increase in duration which became greater as syllables were added to the phrase structures under study. This unusual pattern could be explained by the memory limitations of the learners. The corpus included sentences which may have been unusually long

and syntactically complex, thereby being harder to recall during the recording session. In fact, EL1 participants showed more effort when recalling these longer sentences.

However, the most important goal of this preliminary analysis was to see if English L2 learners of French would transfer the alleged tendency in English to compress the duration of additional syllables to their production in French. Results did not show such tendency. In fact, the almost identical curves for EL2, CF, and EF suggest that the most experienced learners of French produced a temporal rhythmic pattern almost identical to the one displayed by native speakers. This similarity between EL2 and CF is particularly striking in Table 5-3, Figure 5.2, and Figure 5.3. The former, Figure 5.2, presents the relative increase in duration of the measured phrase structures for each speaker group. The latter, Figure 5.3, shows the unaltered duration of each additional syllable within the phrase structures. As can be seen in these two figures, EL2 and CF speakers exhibit almost identical patterns. The magnitude of the variations on RG3, RG4, and RG5 is practically identical. This similarity suggests that the advanced learners of French have acquired the French temporal rhythmic pattern.

In contrast, EL1 speakers produced durational variations which are almost the reverse of the ones showed by EL2 speakers. These variations resemble the ones that native speakers of English exhibited in the production of the English corpus, at least for RG2 and RG3. The addition of the last two syllables to the French sentences has evidently caused some problems to the less experienced learners (EL1). This partial resemblance between the curves of the speaker groups EL1 and English suggests transfer from English to French, at least for the shorter rhythmic groups.

	EL1		EL2		CF		EF		English	
	UDur* (s)	*UI*** *(% I.)*	UDur (s)	*UI (% I.)*	UDur (s)	*UI (% I.)*	UDur (s)	*UI (% I.)*	UDur (s)	*UI (% I.)*
RG1	0.3977		0.2868		0.2678		0.2517		0.3964	
RG2	0.5194	*0.1217 (30.60)*	0.4044	*0.1177 (41.04)*	0.3775	*0.1097 (40.97)*	0.3563	*0.1046 (41.57)*	0.5037	*0.1074 (27.09)*
RG3	0.7101	*0.1907 (36.72)*	0.5813	*0.1769 (43.74)*	0.5422	*0.1647 (43.64)*	0.4778	*0.1215 (34.10)*	0.6630	*0.1592 (31.61)*
RG4	1.0243	*0.3142 (44.24)*	0.7686	*0.1872 (32.21)*	0.7003	*0.1580 (29.14)*	0.6285	*0.1508 (31.55)*	0.7800	*0.1171 (17.66)*
RG5	1.3284	*0.3040 (29.68)*	0.9783	*0.2097 (27.29)*	0.8896	*0.1893 (27.04)*	0.7931	*0.1646 (26.19)*	0.9627	*0.1827 (23.42)*

Table 5-3 Durational increases of the measured phrase structures in both English and French for each speaker group.

*** This column presents the unaltered durations (UDur), in seconds.**
**** This column presents the unaltered increase in duration (UI), followed in parentheses by the increase relative to the duration of the previous syllable (%I.). This increase was computed according to the following formula:**

Relative increase = (Dn+1 – Dn) x 100 / Dn
where:
Dn = duration of the n^{th} syllable.

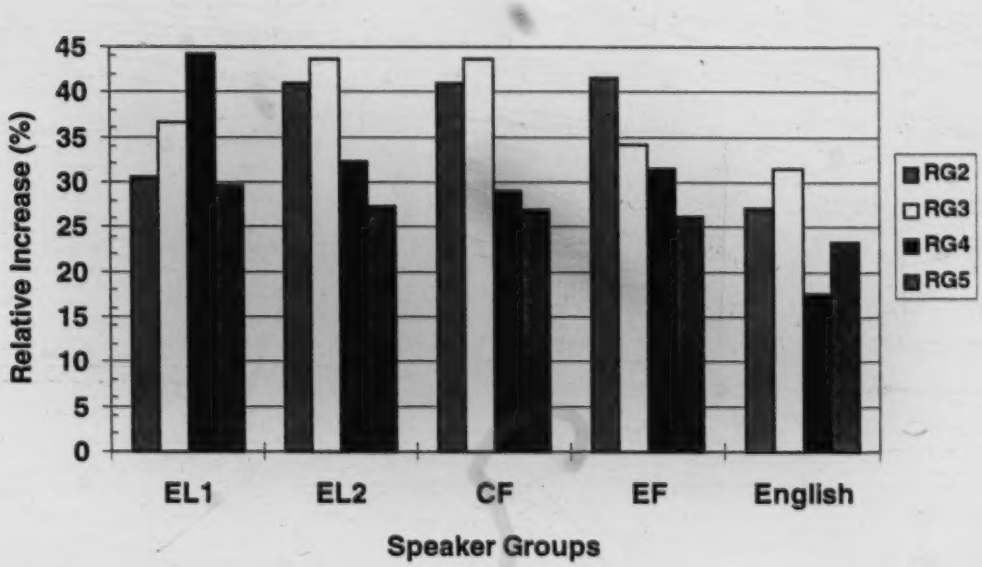

Figure 5-2 Relative durational increase across speaker groups.

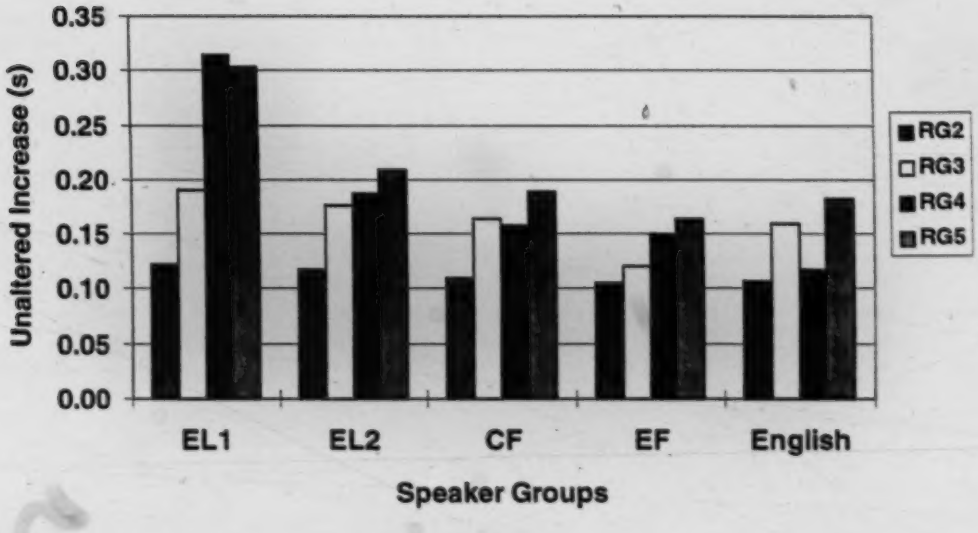

Figure 5-3 Unaltered duration of each additional syllable across speaker groups. RG2 (one extra syllable), RG3 (two extra syllables), etc.

5.2 The Variability Index

This section examines the results of using the variability of syllabic duration in phrase structures under study as measured by an index. The computation of this index will provide information on how much variability speakers exhibit in both languages. This investigation will attempt to answer the following experimental questions: a) how much variability in their syllabic duration do English L2 learners of French exhibit in French compared to native speakers? b) does this variability in French decrease when the level of proficiency increases? This section will examine the results of the English corpus first. Second, a description of the analysis on the French corpus will be presented, including some additional analyses. Finally, the results from these two analyses will be discussed in the last section.

The analysis of the inter-syllabic variability among speakers will be based on the computation of the VarIndex, as explained in section 5.1.4. This

index will allow for a global evaluation of the rhythmic temporal structure of both English and French. More importantly, it will provide empirical evidence of the rhythmic temporal pattern of English L2 learners of French. In this analysis of the French Recall corpus, learners of French were expected to exhibit a greater VarIndex than native speakers of French, hence indicating more variability in their syllable durations. Another expectation was that EL2 would exhibit a VarIndex that would be closer in value to both groups of native speakers of French than EL1's, thereby suggesting the acquisition of a durational pattern closer to French native speakers'. In addition, both groups of L2 learners of French should exhibit greater standard deviation than both groups of native speakers of French. Finally, it was expected that both groups of native speakers would exhibit an almost identical VarIndex.

5.2.1 The English Corpus

The English corpus was used in order to establish a comparison between the learners' indexes in their mother tongue and in their L2. This corpus included the three longest sentences from five sentence groups produced by six native speakers of English. The reason for using only the longest sentences is that a minimum of three syllables is required to compute the index. Detailed methodological information is provided in Chapter 3. A two-way ANOVA was performed on this corpus. The statistical design specified Speakers nested within Speaker Group and Sentences nested within Rhythmic Group as main factors. The overall design for this English corpus was 3(2) x 3(5). Speaker and Sentence were declared random. VarIndex was the dependent variable and the total number of sentences produced by the 6 English speakers was 90. The possible statistical effects are listed below:

Main effects and Interactions
Rhythmic Group
Speaker Group
Sentence (Rhythmic Group)
Speaker (Speaker Group)
Speaker Group * Rhythmic Group
Rhythmic Group * Speaker (Speaker Group)
Speaker Group * Sentence (Rhythmic Group)
Speaker * Sentence (Speaker group * Rhythmic Group)

Main effects and interactions between all factors for the ANOVA. The parentheses indicate nesting.

The statistical software used for all statistical analyses was SPSS version 10.0.

The ANOVA revealed a significant Rhythmic Group effect ($p<.05$). This effect is indicated in Table 5.4 and Figure 5.4. As shown, the value of the VarIndex increases as the phrase structures become larger, going from 0.2454 to 0.5033.

Rhythmic Groups	VarIndex	Standard Deviations
RG3	0.2454*	0.1443
RG4	0.3314	0.2108
RG5	0.5033*	0.1457
Average:	0.3601	0.1995

Table 5-4 VarIndex for the English corpus across rhythmic groups.

*** Significantly different means as determined by a Tukey HSD test.**

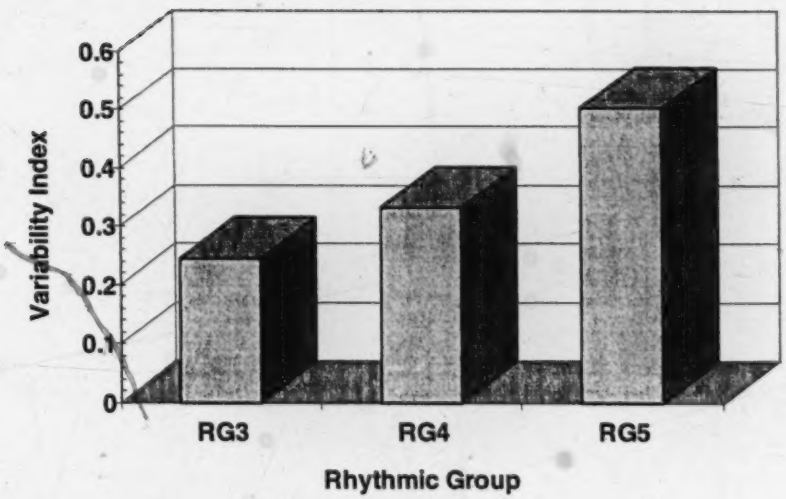

Figure 5-4 VarIndex for the English corpus across rhythmic groups.

It is interesting to notice that the standard deviation is noticeably greater for RG4 (0.2108) than for RG3 or RG5. This greater variation between the indexes measured in sentences belonging to RG4 is caused by the production of a noticeably greater VarIndex for sentence 3 ("Jim would not have seen Mary at the window.") and a noticeably smaller VarIndex for sentence 4 ("Paul would not have liked to hunt."). In sentence 3, the very high indexes occur because of a large difference in duration between the words "would" and "have". In sentence 4, however, the same two words do not display such a large difference in duration. In fact, they are produced with a very similar duration, creating a very low VarIndex. At this point, it is undetermined what may have caused such great differences between sentences which are relatively similar in structure. Table 5-5 and Figure 5-6 illustrate the indexes for all sentences included in RG4.

Sentences	VarIndex
Sent. 1	0.2489
Sent. 2	0.3166
Sent. 3	0.6104
Sent. 4	0.1817
Sent. 5	0.2995

Table 5-5 VarIndex for RG4, English corpus.

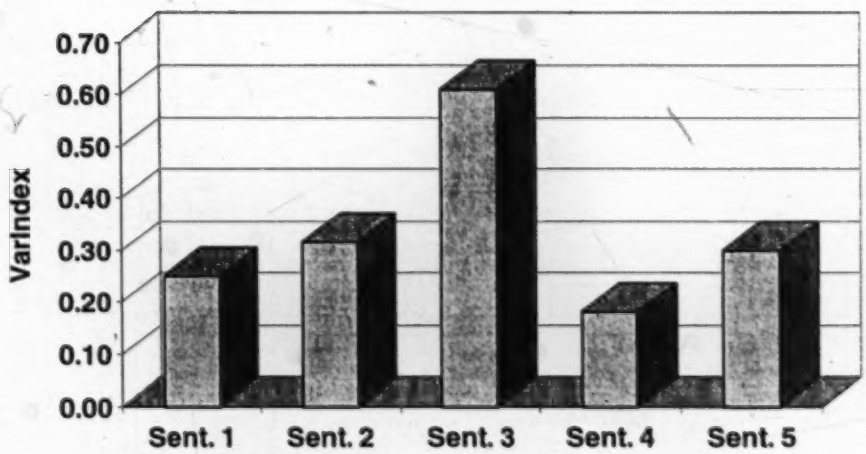

Figure 5-5 VarIndex for RG4, English corpus.

5.2.1.1 Discussion

The first goal of this short analysis was to establish a baseline for the inter-syllabic variability in English, in a syntactic environment that would allow for comparison with the French corpus. The second goal was to determine if any other factors involved in the analysis would have an effect on the VarIndex. Results show that there is one factor which has a statistically significant effect, namely the number of syllables involved in the measured phrase structures.

The explanation behind this increase of inter-syllabic variability with the addition of syllables within the clause is not clear. One explanation could be

that a greater number of syllables with a different phonemic structure in the longer sentences caused this greater index. Sequences of V and CVC syllables, for instance, could cause more durational variability. However, a closer look at the data shows an identical proportion of syllables with a different syllable structure in all three rhythmic groups. Each rhythmic group has one sixth of its syllables which are different from the more common English structure, namely CVC. These different structures are either V, CV, or CVCC. Because of the relatively small proportion of these different structures, it is unlikely that they account for greater syllabic variability in the English corpus. A second explanation could be proposed related to the syntactic nature of the additional monosyllabic words in the measured phrase structures. Many of the sentences which display a greater VarIndex included the auxiliary "have". English auxiliaries are very often reduced in normal speech, producing a noticeably shorter syllable and, therefore, more variability in the duration of syllables.

The values reported for the longest stretches of utterance (RG5) are comparable to the ones reported by Deterding (2001). In his study, he reported an index of 0.543 with a standard deviation of 0.172 for British English. No other significant effect was reported in the ANOVA. In order to allow comparison between this analysis and the planned one for the French corpus, it was decided to investigate the possibility of a Speaker Group effect. In the ANOVA, speakers who belong to EL1 and EL2 were assigned a different code. The results did not show a significant effect of this factor ($p = 0.710$).

5.2.2 The French Corpus

This section presents a detailed analysis of the French corpus. This corpus was recorded by all speakers in a controlled environment. The reader can refer to Chapter 3 for more information about the methodology used in collecting the data for this analysis. As with the corpus of English analyzed in the preceding section, this corpus includes only the three longest sentences of

each sentence group produced by all 12 participants. A two-way ANOVA was performed on the data. The design of this analysis specified, as main factors, Speakers, nested within Speaker Groups, and Sentences nested within Rhythmic Group. This resulted in an overall factorial design of 3(4) x 6(3). The dependent variable was the VarIndex measured and Speaker and Sentences were declared random. The total number of tokens analyzed was 216.

As explained in greater detail in the following section, the statistical analysis revealed a significant difference between Speaker Groups and between Sentences (as nested within Rhythmic Groups).There was also an interaction effect between Speaker Group and Sentence. As expected, no statistical difference was found for Speakers within Speaker Group.

5.2.2.1 Main Effects for Speaker Group

The ANOVA revealed a significant difference between *Speaker Group* ($p<.05$). Table 5-6 and Figure 5-6 present the indexes averaged across all speaker groups (see Appendix B1 for a complete ANOVA table). Both groups of native speakers of English learners of French, EL1 and EL2, exhibited a VarIndex and standard deviations noticeably greater than the other groups. In fact, the VarIndex of EF speakers is almost 30% smaller than the one exhibited by EL1 or EL2. A post-hoc comparison using Tukey HSD revealed that the indexes of both groups of learners, EL1 and EL2, differed significantly from EF but not from CF (Appendix B2). Surprisingly, the level of proficiency did not seem to be associated with significantly lower VarIndex, as EL2 exhibited an index almost identical to EL1. This comes as a surprise considering that one of the main hypotheses of this study stated that the more experienced learners would display a significantly lower amount of inter-syllabic variability in French. The results of this analysis also show a noticeable, although not significant, dialectal effect. EF speakers exhibit a noticeably lower indexes than CF.

Speaker Group	VarIndex	Standard Deviation
EL1	0.4056*	0.2486
EL2	0.4298*	0.2399
CF	0.3508	0.2042
EF	0.2866*	0.1547

Table 5-6 VarIndex by Speaker Groups for the French corpus.

*** Statistically significant pairs of means according to the Tukey HSD test.**

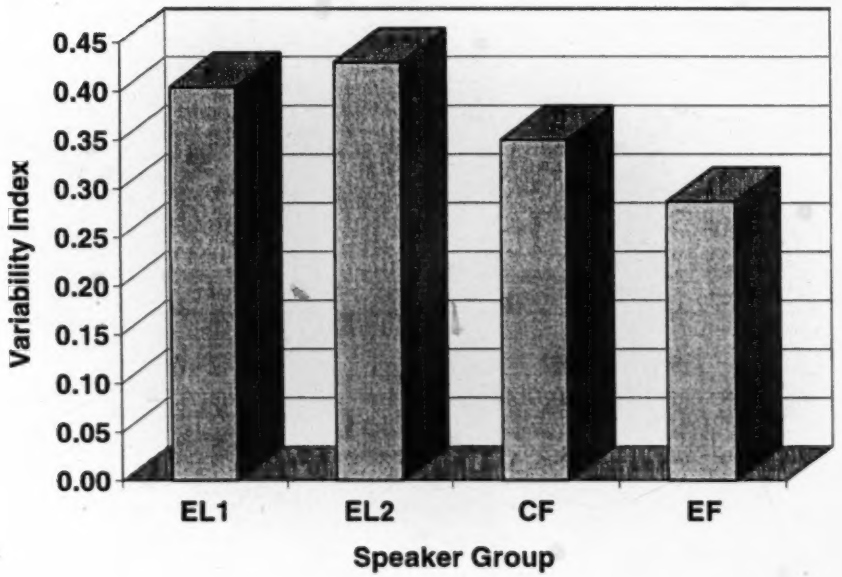

Figure 5-6 VarIndex by Speaker Groups for the French corpus.

The absence of a clear difference between the VarIndex of EL1 and EL2 speakers motivated a closer examination of the results. Table 5-7 and Figure 5-7 present these results. Individual indexes were scrutinized in order to see if, as expected, speakers who have a greater proficiency ranking in Experiment 1 (see Chapter 4) display a lower VarIndex. In general, the inter-syllabic variability and the proficiency ranking are inversely related, as expected. For instance, KB displays a lower VarIndex than AK and CW, and a greater

proficiency ranking. However, there are two exceptions to this tendency. AL and KB have a similar VarIndex but a very different ranking. Similarly VR, who has been assigned the lowest proficiency ranking, should have displayed the highest VarIndex. However, VR's VarIndex is lower than CW's and AK's who are more advanced learners. A closer look at these shows no direct relationship between the VarIndex and the age of learning. Similarly, the time spent in a French environment does not seem to solely provide an account for the indexes measured in this analysis.

Speaker Group	Speakers	VarIndex	Proficiency Ranking	Age started learning French *	Immersion or Time in a French Environment
EL1	VR	**0.4196**	1.6	10	none
	AL	**0.3874**	3.3	14	10 months
	CK	**0.3507**	4.4	8	5 weeks
EL2	CW	**0.4355**	3.9	13	15 months
	AK	**0.4362**	4.9	26	7 years
	KB	**0.3836**	5.8	15	13 years
CF	HV	**0.3924**	7	n/a	n/a
	AG	**0.3448**	7	n/a	n/a
	VB	**0.3131**	7	n/a	n/a
EF	VE	**0.2786**	7	n/a	n/a
	JD	**0.2763**	7	n/a	n/a
	MC	**0.3125**	7	n/a	n/a

Table 5-7 VarIndex and Proficiency ranking for individual speakers.

*** The data regarding the age at which the participants started learning French and the time spent in immersion are taken from Table 3-1.**

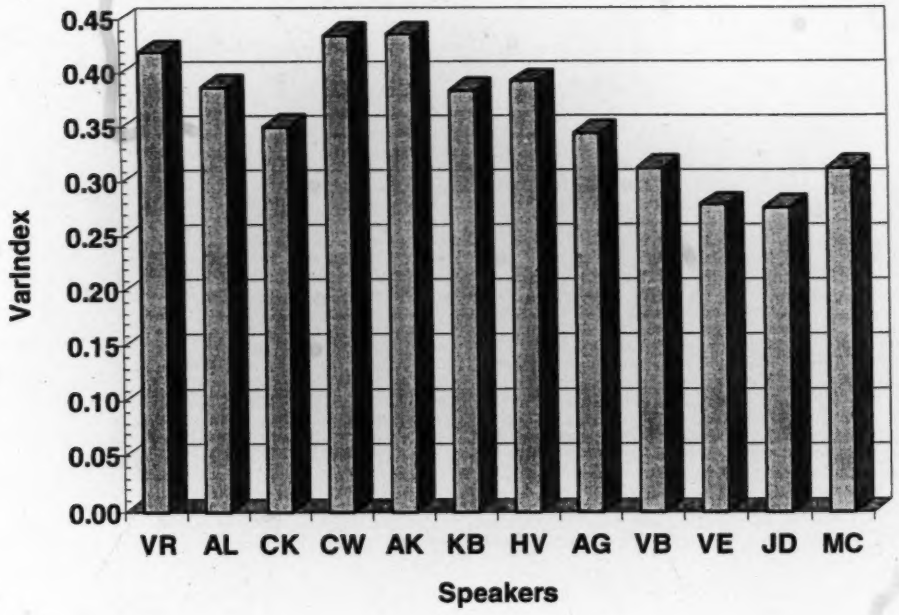

Figure 5-7 VarIndex for individual speakers.

5.2.2.2 Main Sentence Nested Within Rhythmic Group Effect

The ANOVA indicated a second statistically significant effect, namely Sentence nested within Rhythmic Group ($p < .001$). This indicates that the VarIndex of some sentences is significantly longer or shorter than others. For instance, Sentence 1 in all three Rhythmic groups[14] has caused speakers to produce a greater VarIndex than most of the other sentences. On the contrary, Sentences 4 and 6 in RG3 were produced with a very low VarIndex for all groups of speakers. Table 5-8, in conjunction with the bar graph in Figure 5-8, illustrates the differences among all sentences.

[14] There are six sentences in each rhythmic group, one corresponding to each sentence group in the Recall corpus. Thus, RG3S1 refers to the first stimuli (the first sentence group) which has three syllables in the measured phrase structures.

A post-hoc analysis using a Tukey HSD test revealed that the highest peaks (above 0.50) on the graph yielded a significant difference when paired with most but not all means involved in the analysis (see Appendix B3 for results of the post-hoc analysis). These significant differences may be attributed to the presence of a short vowel immediately followed by a syllable with a long French nasal vowel, as in sentences RG3S1 (*Luc a mang*é et s'est endormi.) and RG4S1 (*Luc qui a mang*é s'est endormi.). Such sequences of a short and a long syllable create a high VarIndex for all groups of speakers. In RG5S1 (*Luc qui aurait mang*é se serait endormi.), the presence of a nasal vowel was sufficient in creating a greater index. Similarly, the presence of a complex onset like /br/, found in RG4S5 (*Rome qui a brû*lé serait détruite.), when preceded by a syllable with a single vowel as nucleus, generated a high VarIndex. Sentence RG5S4 (*Paul avait bien a*imé la chasse.) also yielded a greater VarIndex, mostly caused by the presence of the complex onset /bj/ in the word "bien".

Sentences (Rhythmic Groups)	RG3	RG4	RG5
S1	0.7250	0.6339	0.3675
S2	0.3836	0.2274	0.2817
S3	0.3740	0.3177	0.3074
S4	0.2317	0.3238	0.5145
S5	0.3204	0.5367	0.3314
S6	0.2119	0.2798	0.2597

Table 5-8 Averaged VarIndex for the interaction of Syllable and Rhythmic Group.

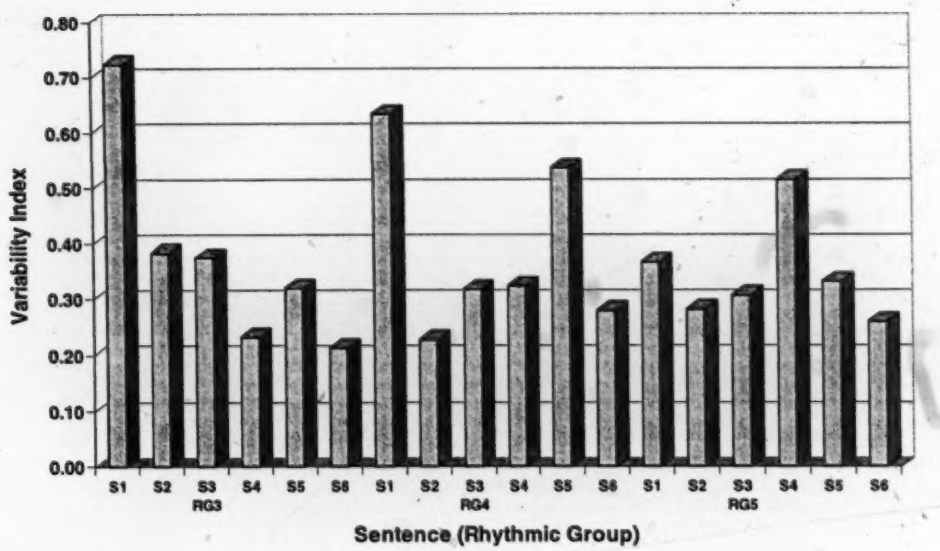

Figure 5-8 Averaged VarIndex for the interaction of Syllable and Rhythmic Group.

5.2.2.3 Speaker Group by Sentence Nested Within Rhythmic Group Interaction

Also of interest is the significant interaction of the factor Speaker Group with the factor Sentence nested within Rhythmic Group ($p<.05$). This interaction means that some groups of speakers exhibit significant differences in the VarIndex produced for the same sentences. In general, it was expected that the speakers groups would exhibit a decreasing VarIndex from EL1 to EF, with EL2 located in between. CF speakers were expected to display similar values as EF speakers. As shown in Table 5-9 and Figure 5-9, a total of eight sentences generally followed this expected order (RG3S1, RG3S3, RG3S6, RG4S2, RG4S4, RG5S2, RG5S3, RG5S4). There is another series of five sentences (RG3S4, RG3S5, RG4S5, RG5S1, RG5S5) where EL1 displayed a surprising lower index than EL2, but where the other speaker groups followed the expected order (CF > EF). In the remaining 5 sentences, three are produced with a similar index by all groups of speakers (RG4S1, RG4S3, RG5S6). In the last two sentences (RG3S2, RG4S6), CF speakers produce either a noticeably high or low index compared to the other groups of speakers.

A Tukey HSD was used to analyze the 72 means derived from this interaction. Contrary to the expectation the post-hoc comparison did not identify any significant difference between speaker groups for the production of the same sentence. For instance, it was expected that the differences between the four groups would be significant in a sentence like RG4S4, or RG5S4. Instead, means were declared significant only when they were associated with means of different sentences. It is interesting to note however that sentences from the fifth group of sentences are involved three times in this tendency. Reasons for such a tendency found only in one sentence group are unknown at this point.

Rhythmic Groups	Sentence	EL1	EL2	CF	EF
RG3	S1	0.8060	0.8304	0.8111	0.4523
	S2	0.3548	0.3719	0.4782	0.3294
	S3	0.5270	0.5612	0.2021	0.2055
	S4	0.1597	0.3919	0.2661	0.1090
	S5	0.0926	0.4648	0.5010	0.2232
	S6	0.4754	0.1380	0.1638	0.0704
RG4	S1	0.6846	0.6804	0.5374	0.6334
	S2	0.4023	0.2198	0.1481	0.1392
	S3	0.2688	0.3421	0.3352	0.3247
	S4	0.5627	0.3465	0.1696	0.2164
	S5	0.3472	0.6389	0.6758	0.4848
	S6	0.4109	0.3007	0.1388	0.2688
RG5	S1	0.2501	0.4826	0.3601	0.3772
	S2	0.3587	0.3206	0.2343	0.2133
	S3	0.3890	0.3677	0.2609	0.2120
	S4	0.6735	0.6241	0.3991	0.3613
	S5	0.2319	0.4908	0.3305	0.2725
	S6	0.3061	0.1643	0.3021	0.2662

Table 5-9 VarIndex across all speaker groups for each syllable within the rhythmic group.

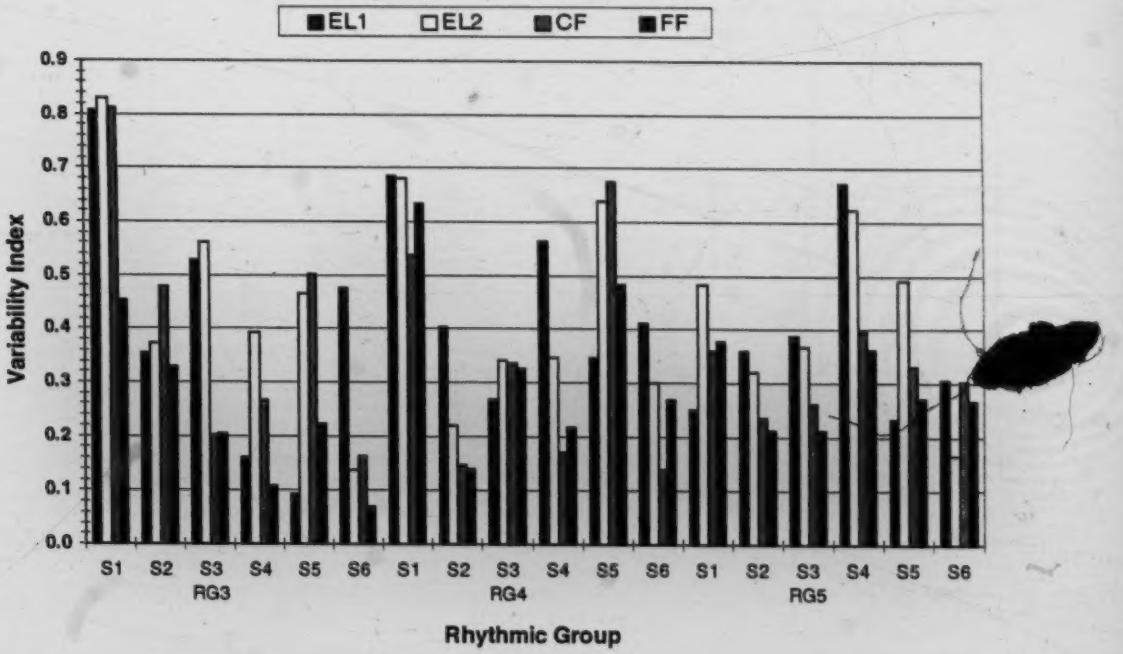

Figure 5-9 VarIndex across all speaker groups for each syllable within the rhythmic group.

5.2.2.4 Discussion

The previous analysis investigated the inter-syllabic variability in French in a production task by English L2 learners and native speakers of French. It was expected that English speakers would display greater variability, as measured with the VarIndex, than native speakers of French. This prediction was confirmed. The statistical analysis also revealed two additional effects: a) Sentence nested within Rhythmic Group, b) the interaction of Speaker Group by Sentence Nested Within Rhythmic Group. These are interpreted as an indication that the quality of the segments involved in the stimuli, as well as the syllabic structure, determine the duration of French syllables. Also, it was expected that more experienced learners, EL2, would exhibit a lower index than the less experienced learners, EL1. This prediction was not completely verified. There is however, some empirical evidence that supports the hypothesis. This issue will be discussed in further detail at the end of this

chapter. Finally, results show consistent differences between speakers of the two dialects of French. None of these latter differences was considered statistically significant however.

It could be argued that these tendencies would have been different had we considered the effect of the group-final syllables in the computation of the VarIndex. A similar analysis was carried out to determine if the results would be confirmed once the final syllable is included in the computations. Table 5-10 and Figure 5-10 present the results of the measurements. The corpus Recall A and Recall B refer to the corpora excluding and including group-final syllables respectively. As can be seen, the values in the two contexts are almost identical. A two-way ANOVA similar to the previous analysis was performed on this new set of data (see Appendix B4 for the results). The analysis identified as significant the same factors as in the previous analysis. There was a main effect for the Speaker Group ($p<.05$), a second main effect for Sentences nested within Rhythmic Group ($p<.001$) and an interaction between Speaker Group and Sentence nested within Rhythmic Group effect ($p<.05$). A post-hoc Tukey HSD confirmed the presence of a significant difference between EL1 and EF.

Unlike the previous analysis, the difference between EL2 and EF was not significant but was very close to significance level (see Appendix B5 for the detailed results). This suggests that the addition of the final syllable in the calculations, at least on relatively short sentences, does have a certain influence on the computation of the indexes. These results confirm the tendency for EL1 speakers to produce more variability than EL2 speakers. As well, the gradually decreasing indexes from EL2, CF, and EF speakers found in the previous analysis is confirmed. Finally, the standard deviations are greatest for learners of French and lowest for EF speakers, as in the initial series of measurements.

Speaker Group	Recall A**	Standard Deviation	Recall B***	Standard Deviation
EL1	0.4056*	0.2486	0.3845*	0.2321
EL2	0.4298	0.2399	0.4143	0.2336
CF	0.3508*	0.2042	0.3501	0.2056
EF	0.2866*	0.1547	0.2891*	0.1575

Table 5-10 VarIndex across Speaker Groups for two series of measurements from the Recall corpus in French: Recall A (without the final syllable), and Recall B (including the final syllable).

*** Statistically significant pairs of means according to the Tukey HSD test.**
**** Measurements do not include the group-final syllable.**
***** Measurements include group-final syllables.**

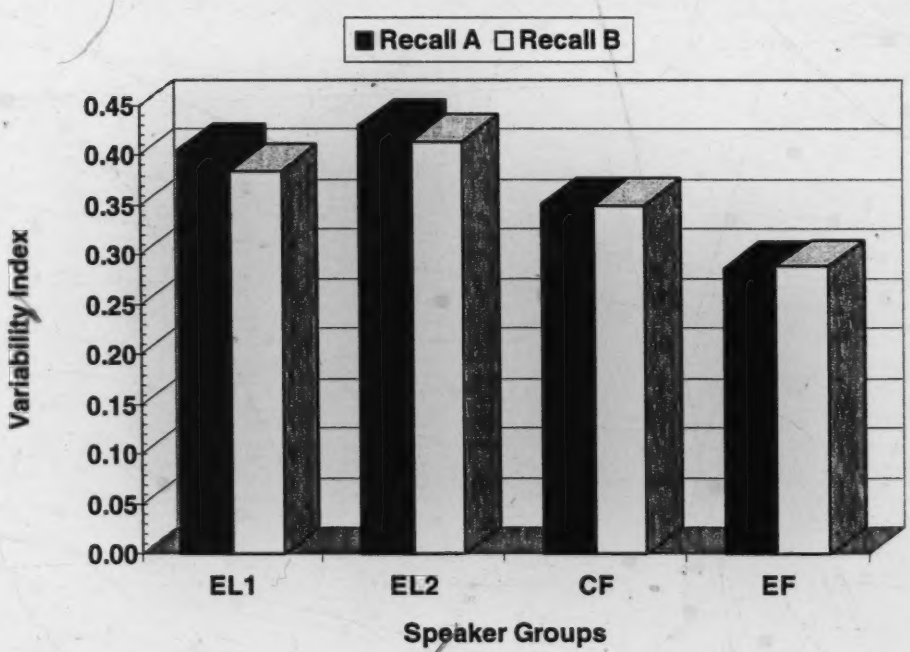

Figure 5-10 VarIndex across Speaker Groups for two series of measurements from the Recall corpus in French: Recall A (without the final syllable), and Recall B (including the final syllable).

5.2.3 The Normalized Duration

The previous analysis determined that factors like the quality of the segments involved or the syllable structure must be taken into consideration in

the computation of the inter-syllabic variability. The present section will attempt to determine if the position of the syllable within a rhythmic group in French also has an influence on the syllable duration. The classification of French as a syllable-timed language implies that all syllables tend to have similar duration. However, a gradual increase in duration throughout the rhythmic group has previously been suggested (Wenk & Wioland 1982). This analysis will also investigate the possibility that English L2 learners of French produce different temporal variations than native speakers of French.

In order to investigate this phenomenon, an ANOVA was performed on the normalized durations of each syllable within the rhythmic group. The use of such an ANOVA requires a constant number of syllables. Therefore, sentences with the greatest number of syllables, and hence the longest rhythmic groups, were used for the computations. A total of 5 sentences from the French Recall corpus were used for this analysis (the longest sentence from each sentence group and produced by all speakers).

5.2.3.1 Position Effect Within the Rhythmic Group

The analysis included the duration measurements of the first but not the last syllable of the rhythmic group. The following example illustrates which syllables were used in the analysis:

"Luc qui au-rait man-gé se serait endormi."

Raw durations were normalized in order to account for speech rate variations. The formula used in this normalized procedure is described in section 5.1.3. The design used for this ANOVA was similar to that used in the preceding analyses. The main factors were Sentence (nested within Syllable) and Speaker (nested within Speaker Group). *Ndur* was the dependent variable. The variables Sentence and Speaker were declared random. The overall design was 6(5) x 3(4).

The ANOVA revealed three significant effects (see Appendix B6 for a complete table). First, there is a significant main effect for Syllable ($p<.001$). In fact, Table 5-11 and Figure 5-11 clearly show that the first syllable of the measured structures was produced with longer duration than any other syllable. A post-hoc comparison using Tukey HSD revealed a significant difference between the first syllable and any of the other means analyzed (see Appendix B7). The last syllable was also significantly longer than syllable 2 or 3. Another interesting tendency shown in Figure 5-11 is the gradual increase in duration as the syllables become closer to the right end of the rhythmic group.

Syllables	Normalized Duration (%)
Syllable 1	1.598*
Syllable 2	0.696* †
Syllable 3	0.640* †
Syllable 4	0.885*
Syllable 5	1.055 †

Table 5-11 Averaged normalized duration of all syllables within RG5.

*** and † indicate significantly different pairs of means according to the Tukey HSD test.**

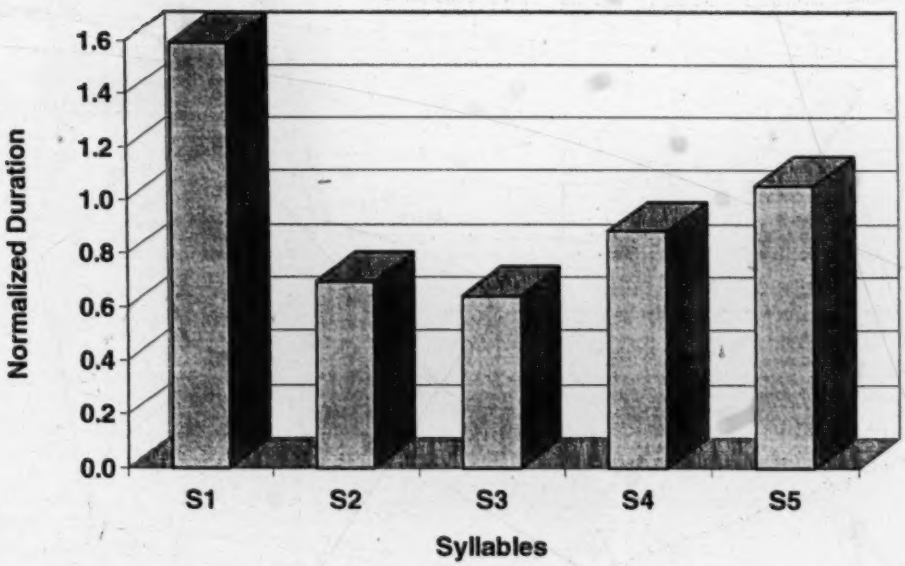

Figure 5-11 Normalized duration of all syllables within a rhythmic group.

The same ANOVA also revealed a second significant effect involving the factor Sentence nested within Syllable ($p<.001$). This effect means that some syllables in specific sentences are produced with a significantly different duration. A post-hoc comparison using Tukey HSD confirmed the differences between the duration of the first syllable of every sentence and other shorter means (see Appendix B8). In addition, this post-hoc procedure revealed significant differences between the means of the first syllable, as indicated in the table. For instance, the means of the 3rd ("Claude") and the 4th ("Paul") sentences were significantly greater than the means of the first and sixth sentences. In the 4th sentence, syllable 4 ("bien") was also significantly greater than all other means except the one associated with the 6th sentence. Another significant pair of means in the 4th syllable is the one involving Sentence 3 ("au-rait") and 6 ("pas") which are short and long syllables respectively. Similarly, Sentence 4 in Syllable 5 (bien aimé) is significantly shorter than all other

means associated with Syllable 5, except Sentence 6. The results are presented in Table 5-12 and Figure 5-12.

Sentences	Syllable 1	Syllable 2	Syllable 3	Syllable 4	Syllable 5
S1	1.338*†	0.884	0.536	0.645*	1.211*
S2	1.626	0.631	0.669	0.685*	1.174*
S3	1.887**†	0.581	0.751	0.566*†	1.267*
S4	1.820	0.570	0.752	1.115**	0.618**
S5	1.597	0.823	0.547	0.737*	1.121*
S6	1.321*†	0.686	0.587	0.941†	0.941

Table 5-12 Normalized Duration by Sentences Nested Within Syllables.

*** and † indicate significantly different pairs of means as indicated in a Tukey HSD post-hoc analysis.**
**** indicates the greater mean used in all paired comparisons in the Tukey HSD test.**

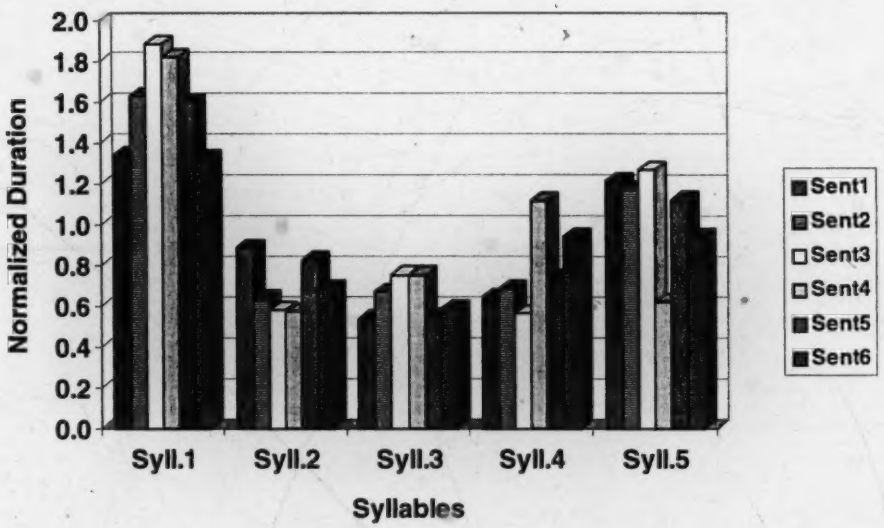

Figure 5-12 Normalized Duration by Sentences Nested Within Syllables.

The ANOVA revealed one more significant interaction between Syllable and Speaker Group (p=0.000). As shown in Table 5-13 and Figure 5-13, the Syllable effect previously identified as significant is confirmed by the Tukey HSD test (see Appendix B9). This analysis reveals that CF and EF produce the

first syllable with significantly longer duration than the 3rd one. More interesting, however, are the differences in the production of a similar syllable. The only significantly different pairs of means are associated with the first syllable. EF speakers pronounce a longer syllable than EL1 and EL2. Contrary to what was expected, no other pair of means was identified as significantly different between speaker groups.

Syllables	EL1	EL2	CF	EF
Syllable 1	1.3708	1.4550	1.6948	1.8723
Syllable 2	0.6106	0.6587	0.7340	0.7795
Syllable 3	0.7324	0.6108	0.6095	0.6086
Syllable 4	1.0087	0.9678	0.7813	0.7815
Syllable 5	1.095	1.0995	1.0623	0.9648

Table 5-13 Normalized duration for all Syllables produced by each Speaker Group.

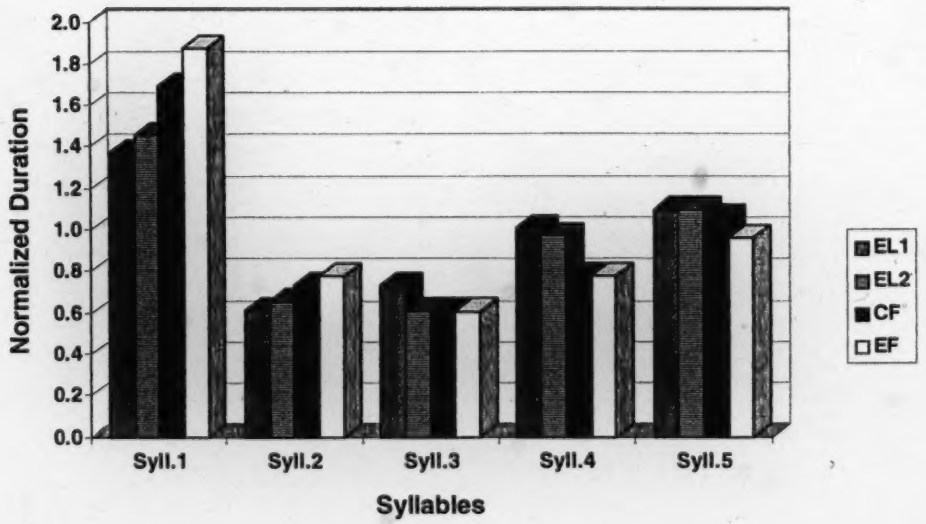

Figure 5-13 Normalized duration for all Syllables within each Speaker Group.

5.2.3.2 Discussion

In summary, the previous analysis on the normalized duration identified three main effects: a) a main Syllable effect, b) an effect of Sentence nested within Syllable, and c) an interaction between Syllable and Speaker Group. It was hypothesized that the position of the syllable within the rhythmic group would have a significant effect on the duration of the syllable. Although this hypothesis was confirmed, it can not be determined if syllable structure, semantic load, position in the rhythmic group, or an interaction of these factors is responsible for the gradual increase in duration. In addition, the analysis confirms the influence of the syllable structure on the duration of the syllables.

The results of the present experiment show a constant and strong tendency for the first syllable to be noticeably longer than all other syllables. This effect has proven very robust statistically. It is possible that the duration of this syllable is determined by the semantic load of the words used in this position, since the first syllable was always a proper name ("Claude", "Paul", "Rome", etc.). However, it seems more likely that this first syllable belonged to a different rhythmic group. In fact, there is empirical evidence which shows that relative clauses, which followed the proper names in the corpus used for this study, constitute an independent rhythmic group. This prosodic boundary is marked on the first element by a major decrease in intonation and duration (Wunderli 1987, Guilbault 1995), which would have caused the proper names to become a complete rhythmic group (formed by a single element).

5.2.4 Free Speech

The goal of the previous experiment was to use empirical data to investigate the temporal properties of English L2 learners of French in the target language. However, it is our opinion that studies done on a laboratory corpus should be confirmed using naturalistic data. In addition, speech rhythm is generally considered to vary according to speaking styles (Astésano 1999, Guaïtella 1991). Therefore, in an effort to determine if the results obtained with

laboratory speech can be generalized to free speech, an analysis of the inter-syllabic variability was devised. This analysis will use the same global evaluation of the syllabic variability provided by the computation of the VarIndex. The goal of this experiment was to determine if the tendencies found in the Recall corpus are also found in free speech.

5.2.4.1 Hypotheses

Since the goal of this experiment was to validate the results obtained with the analysis of the Recall corpus, the experimental hypotheses were the same as that in the previous experiment:

a) all speakers will exhibit more variability in free speech than in Recall speech, and show a greater standard deviation,
b) English L2 learners of French will exhibit more variability in the duration of their syllables in French than native speakers of French,
c) more proficient learners will exhibit less variability, thereby approaching the values exhibited by native speakers of French.

5.2.4.2 Methodological Considerations

The speech material used for this analysis was gathered in the main recording session (refer to Chapter 3 and to section 4.2.3 for a more detailed list of the criteria used). Even though all participants took part in the free speech interview, EF speakers were excluded from this analysis. It was hypothesized that free speech from CF speakers only would provide sufficient evidence to determine if the previous tendencies are verified. Sentences used for this analysis are radically different from the material previously used, being completely unplanned and unrehearsed. The original plan was to collect ten sentences of at least ten syllables from each speaker in order to reach a round figure of 100 syllables for each one of them. However, due to the variable nature of the corpus, it seemed more appropriate to make use of longer sentences to measure a greater number syllables. Therefore, the number of syllables analyzed varies among speakers from 93 to 107. The total number of

sentences and syllables analyzed were 74 and 902 respectively. The actual number of sentences and syllables used are presented in Table 5-14.

	EL1			EL2			CF		
	VR	CK	AL	AK	CW	KB	HV	AG	VB
NUMBER OF SENTENCES	9	9	11	9	7	6	6	8	9
NUMBER OF SYLLABLES	100	94	93	102	102	102	102	103	104

Table 5-14 Number of sentences and syllables analyzed from the free speech corpus in French.

In order to determine if speaker in all groups exhibit different VarIndexes, a one-way ANOVA was performed on the data using SPSS 8.0. The dependent factor was the VarIndex and the independent factor was Speaker Group.

5.2.4.3 Results

The indexes computed for each group of speakers are shown in Table 5-15 and Figure 5-14. These results include the values from the Recall B and Free Speech corpora. The results confirm the first hypothesis, which predicted greater inter-syllabic variability in free speech than in the Recall B corpus. Contrary to our hypothesis, the more advanced learners of French, EL2, displayed a relatively similar index under both experimental conditions. In addition, it was expected that the greater diversity in syllable structure in free speech would create greater standard deviations for all groups of speakers. Again, contrary to our hypothesis, all speaker groups exhibited smaller standard deviation in free speech than during the recall experiment. Finally, the one-way ANOVA performed on the Free Speech corpus revealed a significant Speaker Group effect. The tendency for native speakers of French and EL1 speakers to display significantly different means, as seen in the analysis of the Recall B corpus, was also present in Free Speech. This time, however, the group of native speakers of French includes only CF speakers. The details of this ANOVA are presented in Appendix B10.

Speaker Group	Recall B***	SD	Free Speech	SD
EL1	0.3845*	0.2321	0.5424	0.1740
EL2	0.4143	0.2336	0.4627	0.1185
CF	0.3501	0.2056	0.4844	0.1719
EF**	0.2891*	0.1575		

Table 5-15 Speaker Groups VarIndex from Recall Speech B (including the group-final syllable) and Free Speech.

*** indicates significantly different pairs of means as indicated in a Tukey HSD post-hoc analysis.**
**** No Free Speech sentence were analyzed for EF Speakers. The values from the Recall experiment are inserted only to facilitate comparisons with other groups of speakers.**
***** Data from the Recall B corpus include the group-final syllables in the computation of the VarIndex.**

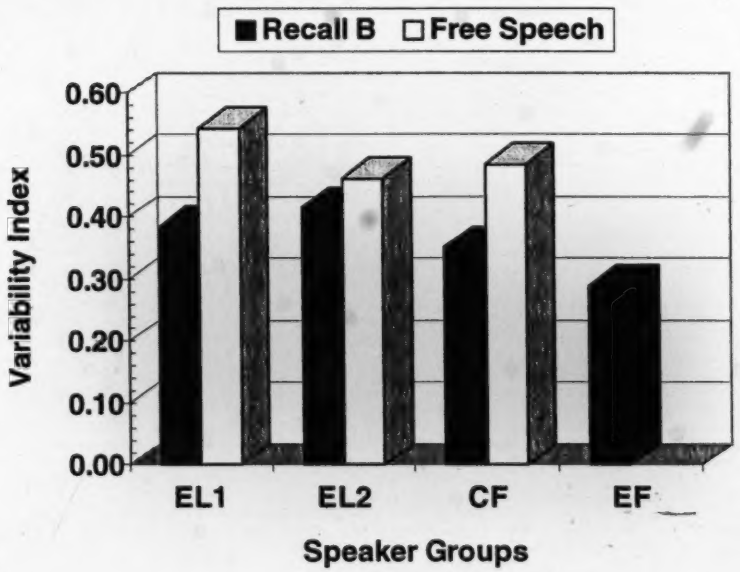

Figure 5-14 Speaker Groups VarIndex from Recall Speech B (including the group-final syllable) and Free Speech.

5.2.5 Discussion

This experiment was designed to compare results from the analysis of the Recall speech material to more naturalistic speech material gathered during the interviews. Similar measurements were taken on approximately 100

syllables for each speaker from the Free Speech corpus in order to determine if previous tendencies would be confirmed. As predicted, EL1 and CF speakers displayed greater VarIndex in Free Speech than in Recall B. This supports the hypothesis that free speech is characterized by the need 'to produce contrasting events' which results in greater inter-syllabic variability (Guaïtella 1999). Unexpectedly, speakers from EL2 exhibited a similar VarIndex in both corpora. This suggests that the absence of extensive formal instruction of French and the frequent immersion experiences in a French community have not provided EL2 speakers with the opportunity to acquire two distinct registers of French, namely a formal and a more casual one.

On the other hand, the different indexes for EL1 learners could indicate that they have acquired two slightly different varieties of French - one which comes from their formal learning environment in school and a second one through exposure to more informal French (television, radio, immersion, etc.). The results suggest that their "school" variety was used in the Recall portion of the main experiment and that the "informal" one was used during the unstructured interview. However, this explanation would contradict Mougeon et al. (to appear) who found that immersion students tend to acquire the standardized variety of French used in school. Moreover, this explanation does not account for a parallel difference between the two speaking styles for CF speakers.

An alternative explanation is suggested by Guaïtella (1999), who claims that rhythmic organization in reading aloud and in spontaneous speech is the result of different cognitive processes. The author argues that reading a written text consists in an oral rendition of a pre-established structure, which favours a metrical structure. This structure is characterized by a more controlled and regulated speech. Spontaneous speech does not have the pre-established structure and must rely on the production of contrastive speech events by the speaker to indicate prosodic-group boundaries. If, therefore, as Guaïtella

suggests, greater variation is inherent to the use of spontaneous speech, the indexes displayed by CF speakers would be predictable.

Additional empirical evidence comes from an instrumental analysis of the production of speech in different styles by Astésano (1999). Contrary to Guaïtella (1999), her theoretical approach assumes the existence of a core linguistic system which regulates the rhythmic structure of various speaking styles. Her results clearly show a greater amount of variability in the "Interview" than in the "Reading" speaking styles. Therefore, despite the uncertainty regarding the source of greater variation in Free Speech, it is almost certain that this speaking style will be characterized by greater inter-syllabic variability. Consequently, the most surprising result of this brief analysis is the absence of a noticeable difference between Recall B and Free Speech for EL2 speakers.

5.3 Discussion of the Results of Experiment 2: The Variability Index

The objective of the analyses carried out in Experiment II was twofold: to investigate the acquisition of the temporal properties of French by English L2 learners of French, and to determine if duration, as a fundamental property of the syllable, provides a coherent account of the proposed rhythmic types. Previous studies suggested that English, traditionally considered a stress-timed language, would exhibit greater inter-syllabic variability than French. In addition, it was hypothesized that English L2 learners of French would exhibit more variability during a production task in French and that this variability would decrease in magnitude as speakers become more fluent in the target language. The predictions made were in general confirmed, even though some of the results did not follow the hypotheses. I briefly review and discuss these findings.

The first step of this analysis was to measure the amount of inter-syllabic variability in English and French in a finite and identical set of stimuli.

The analysis of the English corpus showed that English does exhibit greater inter-syllabic variability than French when measured with the VarIndex. The average index for English was 0.3601 with a standard deviation of 0.1995. In French, the native speakers of Canadian French (CF) displayed an index of 0.3508 with a standard deviation of 0.2042. Native speakers of European French (EF) displayed an index of 0.2866 with a standard deviation of 0.1547. These results provide empirical evidence to support the separation between English and French based on their differences in timing as proposed in numerous studies.

The subsequent analyses in this experiment investigated the acquisition by native speakers of English learning French of the temporal rhythmic properties of the target language. A summary of the analysis is presented in Table 5-16 and Figure 5-15. It was hypothesized that the less experienced English L2 learners of French would exhibit more inter-syllabic variability in the target language than native speakers of French, as measured by the VarIndex. The results confirmed this hypothesis, although there was no significant difference found between either group of learners of French and CF speakers. Several factors may have contributed to this greater variability displayed by English L2 learners of French. The statistical analyses suggest that the nature of the segments involved and the structure of the syllables had an effect on the magnitude of this variability. It is not a surprise that the quality of the segments is important. Given the length of the utterances used for the computation of the index, sequences of a short and a long syllable are likely to cause a significant difference on the average syllabic duration. More importantly, the evidence also pointed towards the structure of the syllable as one of the major causes of greater inter-syllabic variability displayed by English L2 learners of French.

At the beginning of this experiment, a secondary hypothesis specified that the more experienced learners of French (EL2) would exhibit noticeably less inter-syllabic variability in French than less experienced learners (EL1). As

shown in Figure 5-15, the empirical evidence in this experiment only partially supports this hypothesis. It was found that EL1 speakers did not display a greater VarIndex than EL2 speakers in the analysis of the Recall B corpus. The reasons for this result are still unclear. One could hypothesize that EL1 speakers, being less comfortable in French, may have monitored their speech noticeably more than EL2 speakers. Obviously, greater monitoring would be beneficial to learners of French because it would allow them to reach their target with more accuracy, thereby enhancing comprehensibility of their speech. If this hypothesis is true, then one could expect that the same speakers would not monitor their free speech as much, and would produce a more genuine amount of inter-syllabic variability. This is exactly what was found in the analysis of the Free Speech corpus. As shown in Figure 5-15, less advanced learners displayed a noticeably (although not significantly) higher VarIndex than the more advanced learners.

One unexpected result of the preceding analyses was the relative similarity between the amount of inter-syllabic variability displayed by EL2 in all corpora. Figure 5-15 illustrates clearly the lack of variability between the VarIndex measured in Recall B, Free Speech, and English. This result is important since it may challenge some of the assumptions of the existing models of L2 acquisition. This point will be discussed more in depth in the general discussion (Chapter 7).

A third and somewhat less important goal of this experiment was to determine if duration, as a primary property of the syllable, can provide an accurate account of English and French rhythmic properties. The relatively clear results presented in this chapter suggest that duration is a key property of the syllable which reflects the rhythmic structure of English and French. Moreover, this property proved to be an effective mean to distinguish between the production of speech in French by English L2 learners at different levels of proficiency.

	French Corpora						English Corpus	
Speaker Groups	Recall A †	SD	Recall B††	SD	Free Speech	SD	English**	SD
EL1	0.4056*	0.2486	0.3845*	0.2321	0.5424	0.1740	0.4281	0.2097
EL2	0.4298*	0.2399	0.4143*	0.2336	0.4627	0.1185	0.4493	0.2344
CF	0.3508	0.2042	0.3501	0.2056	0.4844	0.1719		
EF	0.2866*	0.1547	0.2891*	0.1575				

Table 5-16 Summary of Results. Recall A and B refer to the laboratory corpus, excluding or including the group-final syllable respectively in the analysis.

*** Significant results under one experimental condition.**
**** These values are presented only for comparison with the other corpora.**
† Read Corpus without group-final syllables in the computation of the VarIndex.

†† Read Corpus with group-final syllables in the computation of the VarIndex.

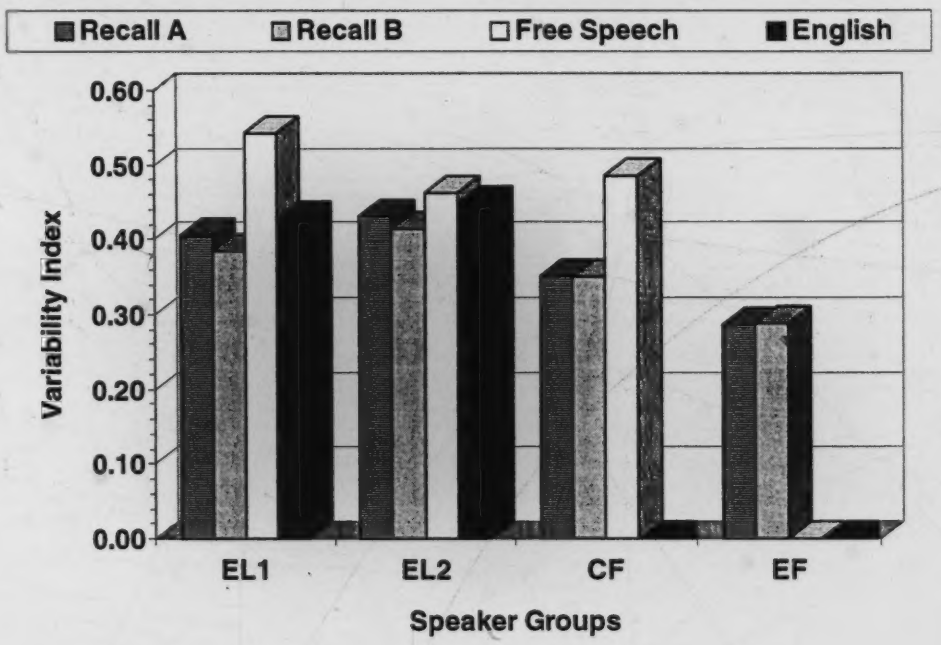

Figure 5-15 Summary of results for the analysis of the inter-syllabic variability.

6. ANALYSIS OF LANGUAGE-SPECIFIC PHONEMIC PROPERTIES

6.0 Introduction

Results from the previous experiment have shown that English L2 learners of French exhibit greater inter-syllabic variability in French than native speakers of French. In addition, it has been shown that inter-syllabic variability in duration is, at least in part, related to the quality of the segments involved. Also, results suggest that this variability is related to the syllabic structure of the language under study. This chapter presents the results of an investigation which attempts to determine what may have caused these differences of variability among all speaker groups.

The current experiment, called Experiment III, is based on the account of rhythm first proposed by Dasher and Bolinger (1982). As explained in Chapter 2, this proposal stipulates that the intuitive rhythmic categories previously established are the result of the cumulative effect of phonological properties of a specific language. For Dauer (1983), these properties can be grouped in two categories. Firstly, the presence of a greater variety of syllable structures in stress-timed languages leads to a higher number of heavy syllables. In addition, in stress-timed languages, stress affects mostly heavy syllables. Secondly, the presence of stressed syllables is associated with the presence of reduced vowels in unstressed syllables. These unstressed vowels are reduced, sometimes to the point where they become non-existent. The cumulative effect of these characteristics has given the long-lasting impression for linguists that some languages differ noticeably in their temporal structure. This is radically different from the traditional view, as it considers rhythm not as a general framework which provides a structure for the temporal organization of phrases and sentences. Instead, it considers that rhythm is *the result* of the particular phonemic properties of a language.

This claim has found empirical validation in Ramus et al. (1999), who demonstrated that a simple measurement of vocalic and consonantal intervals can account for the phonemic differences between languages which belong to different rhythmic categories. In their study, they showed that languages which are usually classified as stress-timed or syllable-timed can be grouped based on the proportion of the time that speakers spend producing vowels compared to consonants. In languages traditionally classified as syllable-timed, speakers spend noticeably more time producing vowels than consonants. This methodology proposed by Ramus et al. provides a new tool that allows for accurate and global evaluation of the phonemic structure of learners' interlanguage. This evaluation is based on a comparison of the intervals measured with the values of well-defined languages like English, Dutch, Spanish and French.

The first goal of the current experiment, therefore, was to investigate the phonemic properties of English L2 learners of French in the target language, as they relate to the rhythmic properties of French. A secondary goal of this experiment was to validate the conclusions of the previous analyses. These analyses relied on the assumption that all speakers syllabified polysyllabic words in an identical manner. It was necessary to make this assumption because of the impossibility of determining, without further experimentation, how speakers had in fact syllabified the corpora. There is empirical evidence, however, that demonstrates that English L2 learners of French exhibit mixed syllable structures, particularly in the earlier stages of acquisition (Beaudoin 1996). The current experiment is based on a different methodology from Experiment II, which allows to make measurements which do not rely on syllable structure. Similar tendencies from this analysis would support the conclusions drawn at the end of the Experiment II.

6.1 Experimental Hypotheses

As noted above, the results reported by Ramus et al. (1999) support the placement of languages in different rhythmic categories based on their basic phonological properties. These language-specific properties are reflected in the phonetic structure and give different vocalic and consonantal intervals. Vocalic intervals refer to the total duration spent producing vowels in an entire sentence. As explained in greater detail in the upcoming section, the vocalic and consonantal intervals are the result of the language-specific phonemic properties. In Ramus et al. (1999), English exhibited a significantly lower percentage of vocalic interval than French (this can be explained by several factors, like the syllable structure for instance, see Dauer 1983). Thus, the authors claim that these vocalic intervals can be used to categorize languages in groups similar to the ones traditionally proposed by Abercrombie (1967) based on their rhythmic properties. Therefore, the first hypothesis in the current analysis was that the analysis of the English corpus would yield a lower vocalic interval than the French corpus produced by native speakers.

In addition, it seemed reasonable to predict that EL1 and EL2, in their production of French, would exhibit interval values located between the values obtained for native speakers of English and native speakers of French. Results from Experiment II showed that English L2 learners of French exhibit greater inter-syllabic variability than native speakers of French. Therefore, greater standard deviations could be expected for the intervals produced by EL1 and EL2 speakers than for CF and EF speakers. Following the results of Experiment II, it was expected that EL2's values would come to resemble the ones displayed by the native French speakers, as the English speakers' level of proficiency in French increases. Similarly, the greater inter-syllabic variation observed for CF than for EF speakers in the previous experiment should be confirmed in this analysis.

The preceding expectations are summarized in the hypotheses below:

a) The proportion of vocalic intervals will be noticeably greater in French than in English,
b) Both groups of French learners (EL1, EL2) will exhibit lower percentages of intervocalic intervals (%V), greater standard deviations for the vocalic intervals (ΔV), and greater standard deviations for the consonantal intervals (ΔC) than both groups of native speakers of French,
c) EL1 speakers will exhibit greater variability as measured by the standard deviations of the consonantal (ΔC) and vocalic (ΔV) intervals than EL2, CF, and EF speakers, and
d) CF will display slightly greater variability in general than EF.

6.2 Methodological considerations and data analysis

Following Ramus et al. (1999), the analysis included vocalic and consonantal intervals. Vocalic intervals are defined by the authors as the speech signal found between the onset and offset of a single vowel or several vowels. Consonantal intervals will be found between the onset and the offset of a single consonant or several consonants. The sum of these two types of intervals would give the total duration of the sentence. For instance, the sentence "Pierre qui a peint travaille beaucoup." would be segmented and measured as follow: /pj.ɛ.rk.ia.p.ɛ̃.tr.a.v.a.jb.o.k.u/. Contrary to Ramus et al. (1999), the sentence-final syllable has not been included in the measurements to avoid inserting irrelevant variations in duration, as explained in Section 5.3.2.

Following Ramus et al., the measurements of consonantal and vocalic intervals will be converted into three different variables:

1) the percentage of vocalic intervals in the entire sentence (%V), which is computed by summing all vocalic intervals, dividing this

figure by the total duration of the sentence, and by multiplying it by 100,

2) the standard deviation of all vocalic intervals within each sentence (ΔV), and
3) the standard deviation of consonantal intervals within each sentence (ΔC).

In order to obtain a sufficient number of measurements, four of the longest sentences for each speaker in both the English and French Recall corpora were chosen for this analysis. Table 6.1 below provides the list of sentences that were measured for this analysis. The slight differences in the number of intervals measured between Speaker groups in Table 6.2 is due to differences in the number of *liaisons*. The least proficient speakers did not produce as many liaisons as the native speakers did.

English corpus:

1- Jimmy would not have seen Mary at the window.
2- Claire who should have been painting works a lot.
3- Paula would not have liked to hunt.
4- Rome which would have been burning would have been destroyed.

French corpus:

1- Rome qui n'aurait pas brûlé serait détruite.
2- Paul avait bien aimé la chasse.
3- Claude ne l'aurait pas vu à la fenêtre.
4- Pierre qui nous a bien peint travaille beaucoup.

Table 6-1 English and French corpora for experiment 3.

The effect of the three measurements (%V, ΔC, and ΔV) was evaluated using three separate two-way ANOVAs. The statistical design was similar for the three statistical analyses. The dependent variable was the vocalic intervals (%V), the standard deviation of consonantal intervals within each sentence (ΔC), or the standard deviation of vocalic intervals within each sentence (ΔV), and the independent factors were *Speakers* nested within *Speaker Groups*.

The overall design for the analysis of this corpus was 1 x 3(4). The factor *Speaker* was declared random. The following section presents the results of the analysis and their statistical significance. The computations were done using SPSS version 10.0.

6.3 Results

Table 6-2 presents the number of measurements, %V, ΔC, and ΔV across all groups of speakers in the French corpus. Even though the statistical analysis must be done separately for the results of the English corpus, they have been included in order to compare the production of English learners in their mother tongue to their production in French. As can be seen in Table 6-2, native speakers of English produced noticeably greater %V when speaking French than English. The percentages varied from 47.21 in English to 57.81 and 53.09 in French for EL1 and EL2 speakers respectively. These results are presented in Figures 6-1 and 6-2. This confirms the first experimental hypothesis.

	Number of V Intervals	Number of C Intervals	%V (SD)	ΔC (SD)	ΔV (SD)
EL1	94	93	57.81* (4.75)	6.38 (2.43)	6.89** (2.78)
EL2	93	93	53.09* (6.77)	5.71 (1.32)	4.72* (1.96)
CF	95	95	53.83 (4.38)	5.84 (1.56)	4.52* (2.39)
EF	99	98	54.98 (4.15)	5.79 (1.99)	3.81* (1.80)
TOTAL:	*381*	*379*	-----	-----	-----
English	225	231	47.21 (5.42)	5.7 (1.62)	4.6 (1.45)

Table 6-2 Number of intervals, percentage of vocalic intervals (%V), standard deviation for consonants (ΔC) and vowels (ΔV).

Variables %V, ΔC, and ΔV have been multiplied by 100 for ease of reading.
* Statistically significant results when paired with "**" mean determined using a Tukey HSD post-hoc procedure.
** Statistically significant results when paired with other "*" means, as determined using a Tukey HSD post-hoc procedure.

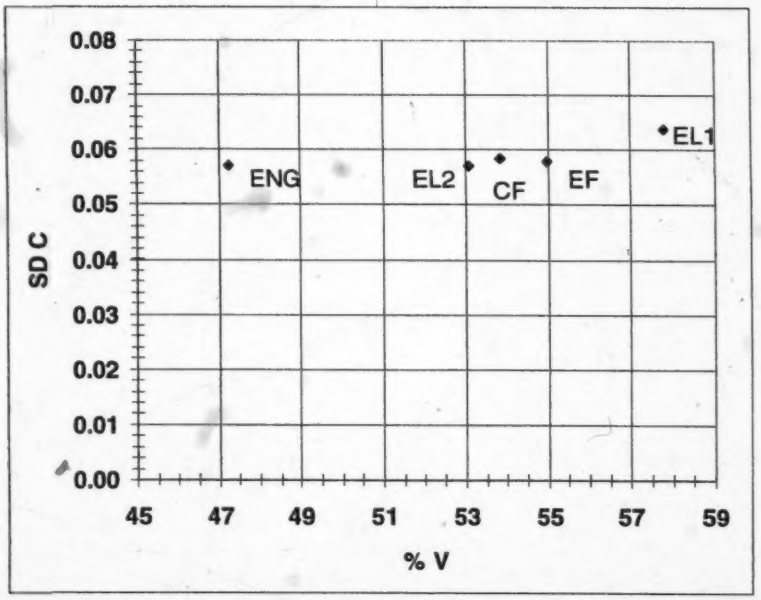

Figure 6-1 Distribution of Speaker Groups and Languages over the %V and ΔC plane.

Note that on this chart, SDC stands for ΔC.

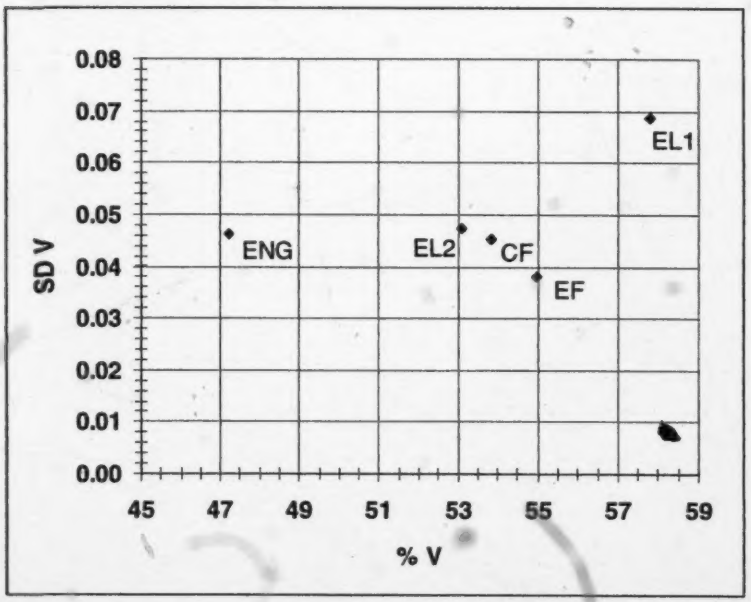

Figure 6-2 Distribution of Speaker Groups and Languages over the %V and ΔV plane.

Note that on this chart, SDV stands for ΔV.

The second hypothesis associates greater %V, ΔC, and ΔV with both groups of English L2 learners of French. Results show that this hypothesis is only partially confirmed. The less experienced learners (EL1) produced distinctly greater %V, ΔC, and ΔV than native speakers of French but the more experienced learners (EL2) did not. For instance, EL1 speakers display a ratio of 57.81% of their time producing vowels, compared to 53.09%, 53.83%, and 54.98% for EL2, CF and EF speakers respectively. This result suggests that L2 learners have successfully acquired the rhythmic properties of French. The first two-way ANOVA (see Appendix C1) computed on these vocalic intervals confirmed the significant difference between Speaker Groups ($p<.05$). The Tukey HSD did not identify any pair of means as significant, but the Tukey LSD[15] test identified EL1 and EL2 as responsible for this main effect (see Appendix C2). There was no significant difference between EL1 or EL2 and the two groups of native speakers of French (CF, EF).

In addition to this first significant effect, EL1 exhibited a tendency to produce greater standard deviation of the vocalic intervals within each sentence (ΔV). The standard deviation displayed by this group of learners is noticeably higher than any other group, at 6.89%. The second two-way ANOVA identified, once more, a significant *Speaker Groups* effect, which a Tukey HSD related to all pairs of means which include EL1 (see Appendix C3 and C4). Contrary to the second hypothesis, the statistical analyses did not reveal a significant main effect for the measurement of standard deviation of the consonant intervals within each sentence (ΔC) and *Speaker Groups* ($p=.848$, see Appendix C5). This result will be discussed further in section 6.5. Finally, it is noteworthy to mention that the variables associated with the more experienced learners of French, EL2, were similar to CF and relatively close to EF.

[15] Indicate the significance of the LSD and the complete name of the statistical test.

The third hypothesis predicted a difference between the two groups of learners of French, EL1 and EL2. As previously explained, EL1 produced significantly greater vocalic intervals, with rates of 57.81 and 53.09 respectively. Similarly, EL1 speakers produced significantly greater variations in the duration of these vowels within one sentence (ΔV), at 6.89%, compared to 4.72% for EL2 speakers. On the contrary, the standard deviation of the consonant intervals within each sentence (ΔC) did not differ significantly between the two groups of learners. These differences between EL1 and EL2 partially confirm the prediction made by the third hypothesis.

The fourth experimental hypothesis was an investigation of the dialectal variations between the two groups of French native speakers. According to this hypothesis, speakers of CF and EF would show significant differences in the time they assigned to the production of vowels. Results show that although the intervals differed between the two groups of speakers, the difference was not significant. The difference between the interval displayed by CF speakers, 53.83%, and the interval exhibited by EF speakers, 54.98% is only 1.15%. As well, speakers of both groups showed a similar ΔC of 5.84 and 5.79 for CF and EF respectively. The two groups of speakers did, however, exhibit a noticeable although not statistically significant difference between their ΔV. The value displayed by CF speakers is noticeably higher than that of EF speakers, at 4.52 and 3.81 respectively.

In order to determine if anyone of the four sentences used in this analysis had an undue effect on the vocalic intervals measured, one more statistical analysis was computed using the *Sentence* factor. In order to create an error term in the analysis, it was necessary to consider the measurements for the four sentences as four replicates for each subject. Therefore, the two-way ANOVA had one dependent factor, namely the measurement of the vocalic interval (%V), and one independent factor, namely *Speaker Groups*.

The factor *Sentence* was declared random for the analysis. The design of the experiment involved no nesting for the two factors with four levels 4 x 4.

As can be seen in Table 6-3 and Figure 6-3, there is a noticeable difference between sentence 4 and sentences 1 to 3. The two-way ANOVA revealed that this effect was significant (p=.000). The Tukey HSD post-hoc comparison indicated a significant difference for all pairs of means which included Sentence 4. It is uncertain why this sentence in the French corpus ("Pierre qui nous a bien peint travaille beaucoup.") triggered significantly lower %V than any other sentence. However, this sentence has more consonant clusters (3) than any of the other three sentences analyzed (which have 1 or 2). Sentence 4 included the following clusters: /pj/("Pierre"), /bj/ ("bien"), and /tr/ ("travaille"). It is likely that this greater number of clusters contributed to the shorter amount of time spent by all groups of participants producing vowels.

Sentences	%V (SD)
1	58.18* (4.24)
2	56.53* (3.80)
3	55.91* (4.86)
4	49.09** (3.12)

Table 6-3 Vocalic intervals for all sentences. "SD" refers to the standard deviation.

** Significantly different results as determined by a Tukey HSD post-hoc analysis when compared with any other mean identified by "*".

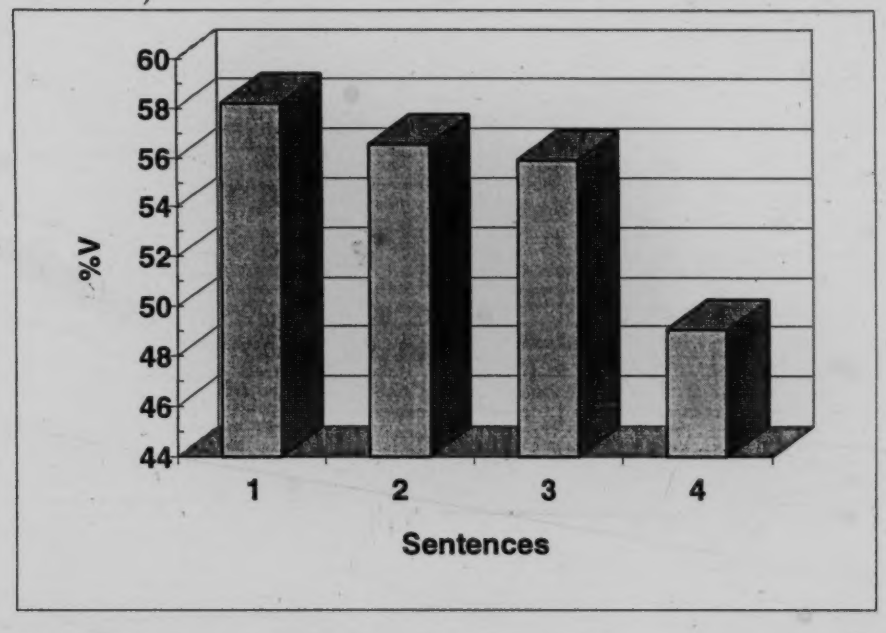

Figure 6-3 Sentence effect for vocalic intervals (%V).

6.4 Discussion

This experiment was an investigation of the phonological properties of French produced by English L2 learners. A portion of the Recall corpus gathered for the previous experiments was reanalyzed with the methodology proposed by Ramus et al. (1999). The main goal was to confirm the greater variability in the production of French by English L2 learners with a different methodology. Furthermore, this experiment attempted to determine if this variation was caused by a specific category of segments, namely vowels or consonants.

The results followed, in general, the experimental hypotheses and, hence, confirmed previous findings. Native speakers of English produced lower %V in English than native speakers of French did in their mother tongue. The values observed in this experiment however are noticeably lower than the ones observed by Ramus et al. (1999). The authors reported a ratio of 40.1% and 43.6% for English and French respectively, compared to 47.21 and 54.98 in

the current study. This discrepancy between our results and the ones found in Ramus et al. is attributable at least in part to the constitution of the corpora. The corpus gathered by Ramus et al. was larger and must have included a wider range of syllable structures, therefore allowing for more consonant clusters. This greater number of consonant clusters would have required a greater amount of time spent articulating consonants, which would in turn have resulted in a lower %V.

In addition to the confirmation of previous findings, the use of vocalic intervals provided a relatively clear picture of the rhythmic differences between native speakers and learners of French. As expected, English L2 learners of French displayed different results in English and in French. EL1 speakers, in particular, exhibited a greater %V in French than in English. What was not expected however is the magnitude of this increase. Results show that they spent even more time producing vowels in French than native speakers of French. This tendency to overextend the production of vowels could be somewhat similar to the phenomenon of hypercorrection where speakers go beyond the target point set by the variety of language that a speaker has (Crystal 1991). This result is interpreted as evidence of the acquisition (at least partial) of the temporal rhythmic structure of French.

There is additional empirical evidence which could explain the great variations found in vowel duration. The process of going from a language where lexical stress causes vowel reduction to a language where there no lexical stress *per se*, is likely to cause less proficient learners to overextend the production of vowels in an effort to make all unstressed vowels longer. This is supported by empirical evidence which demonstrates that speaking rate variations create greater changes in the duration of vowels than consonants (Gay et al. 1974). This is also supported by a study which proposed that changes in the duration of vowels are less likely to affect the intelligibility of the message than changes in the duration of consonants (Guenther 1974).

Moreover, the greater standard deviations displayed by EL1 speakers support the hypothesis that the vowel reduction phenomenon found in English has been partially transferred by EL1 speakers from English into French.

It is also possible that the greater variation regarding the duration of vowels by English speakers was caused by a reduction of their speech rate in order to allow for more planning time. This hypothesis would have to be examined in greater detail in further research. Another reason may have contributed to the additional lengthening of the vocalic segments. The less proficient learners may have been more self conscious of their pronunciation, and they may have tried to monitor their production of the French vowels specifically to ensure proper communication. The French vowel system represents a challenge for the English learners, particularly because of the front rounded vowels, which are not found in English (Valdman 1993:101). It is very likely that during their acquisition of French through several years of formal teaching, instructors emphasized accurate pronunciation of these sounds, thereby causing these learners to become self conscious of the quality of their vowels. The effect of self-monitoring on learners' pronunciation in the target language has been examined in a small number of studies (see Ludlow & Cikoja 1998 for a review). It has been suggested that perceptual-motor interactions may occur specifically "in the development of a perceptual representation of one's own speech used for self-monitoring output". (Ludlow & Cikoja 1998: 508)

Given the results of Experiment II, the differences in this experiment between the two groups of native speakers of French is not surprising. It is interesting to note, however, that these differences are related to the production of vocalic segments. This point will be addressed in more detail in the final discussion of this research.

The Sentence effect revealed by the statistical analysis is interpreted as an indication that syllable structure must be taken into account in the measurement of vocalic intervals. The lower %V value associated with Sentence 4 was taken to be a reflection of the greater number of consonant clusters in onset position, which required a large part of the articulatory activity and time by all speakers. This suggests that the total amount of time spent by speakers producing vowels as measured by vowel intervals is sensitive to the variations in the syllable structure of a sentence in French.

7. DISCUSSION AND CONCLUDING REMARKS

7.0 Summary of Results

The three main objectives of this study were:

a) to investigate the acquisition of French rhythm by English L2 learners; and
b) to further explicate the role of duration in an account of speech rhythm;
c) to use empirical evidence to assess certain theories of acquisition of rhythm in an L2.

The main conclusions of the current research can be summarized by the following statements:

a) the empirical evidence suggests that advanced English L2 learners have modified the temporal properties of their speech in French to better approximate its rhythmic structure,
b) the empirical evidence suggests that duration, as a fundamental property of the syllable, provides a satisfactory account of the rhythmic properties of French, and
c) the empirical evidence suggests that language-specific phonological properties must be integrated into an account of rhythm.

7.1 Discussion

The discussion in this section is organized according to the two experimental questions posed in the introduction to this research. Following is a brief discussion of the possible pedagogical implications of this research.

7.1.1 Do English L2 learners of French acquire the temporal rhythmic pattern of French?

One of the main objectives of the current research was to determine if English L2 learners of French acquire the temporal rhythmic pattern of the target language. The empirical evidence provided in Experiment II and Experiment III clearly demonstrated there is a similarity between the most advanced learners (EL2) and native speakers of French (CF and EF) with respect to their use of temporal rhythmic patterns. In Experiment II, the VarIndex computed on the Free Speech corpus showed a clear difference between the two groups of learners. This tendency, however, was not clear in the analysis of the French Recall B corpus (which included the group-final syllables), where both groups of learners (EL1 and EL2) displayed a similar amount of inter-syllabic variability. This discrepancy may be explained by the monitoring that less advanced speakers may have used during the recording sessions.

Additional evidence for the acquisition of French temporal rhythmic patterns by English L2 learners was provided by Experiment III. The vocalic intervals (%V) and standard deviations of vocalic intervals within each sentence (ΔV) were noticeably greater for EL1 than EL2 speakers. This strongly suggests that the most advanced learners are closely approximating the temporal rhythmic structure of French. In addition, this result is taken as evidence that the temporal properties of vocalic segments are challenging for English L2 learners of French. Many factors may have contributed to the production of a great amount of variability in the duration of vocalic segments of English L2 learners of French. Among these, three specific factors are considered more important. First, the tendency for English L2 speakers to shorten unstressed vowels in French, which is likely to have caused greater variations in duration. It is undetermined at this point exactly how much this factor may have influenced the duration of vowels, but it seems reasonable to

assume that, at least in the early stages of acquisition, this phenomenon is still present.

Second, the presence of a rising intonation, characterized by increased syllable length and rising pitch, on the group-final syllable in some of EL1 speakers' speech may have contributed to the greater durational variations of vowels. This phenomenon seems to indicate a request for some feedback from the listener in the attempt to ensure proper communication. It is likely that this lengthening has mostly influenced the duration of vowels, thereby noticeably increasing the standard deviations. The need for feedback would be greater for less proficient learners, thereby explaining the greater deviation between their results and those of native speakers of French.

Third, it is possible that the greater durational variability associated with the production vowels by EL1 speakers is only the result of the gradual acquisition of the French phonemic system. The French system poses a number of challenges for native speakers of English, specifically regarding the front rounded vowels. In order for students to properly articulate these vowels, an additional amount of concentration and time may very well be required. This difficulty in producing vowels accurately may also be amplified by their desire to acquire the allophonic length distinctions in CF (see below for a discussion on the use of duration in CF). In addition, it is possible that the magnitude of variations displayed by EL1 speakers was caused by a transitory regression period which is part of the acquisition process (U-Shape, see Kellerman 1985). Only a finer analysis involving more speaker groups at different levels of proficiency would confirm this hypothesis.

The progress displayed by English L2 learners of French in acquiring the French rhythmic pattern suggests that a process similar to the one involved in the establishment of new phonetic categories is taking place. The application

of the second and third hypotheses of the Speech Learning Model[16] (Flege 1995) to this research predicted that if differences between the L2 and the L1 rhythmic systems were perceived by L2 learners, a new rhythmic structure would be established. It appears that English L2 learners did establish a new rhythmic structure for French. This suggests that rhythmic differences between the two languages were, in fact, perceived. However, it remains undetermined what were the precise differences perceived by the learners. Further investigation is required to specify the nature of the suprasegmental factors associated with speech rhythm which are perceived by L2 learners. This specific question is closely related to the more general questions regarding the nature of speech rhythm. These will be further discussed below.

The analysis of inter-syllabic variability yielded one unexpected result. The VarIndex values displayed by EL2 speakers are similar in English and in French. According to the fourth postulate (P4) of the SLM, "bilinguals strive to maintain contrasts between L1 and L2 phonetic categories, which exist in a common phonological space." (Flege 1995) The similarity between indexes in English and in French stands in contradiction to this postulate. In fact, this result appears to argue in favor of the opposite hypothesis, namely that bilinguals merge the rhythmic properties of their L1 and L2 so that a single rhythmic structure is used. However, great caution is required before making this claim, as these experiments were not designed as a rigorous test of Flege's (1995) P4. More specifically, it is important to keep in mind that only the acoustic cue of duration has been used in this investigation. It is possible, if not likely, that L2 learners use different acoustic cues, or a different combination of acoustic cues (Repp 1983), in producing the rhythmic structure

[16] The second and third hypotheses of the SLM are described as follows:

of their French. Evidently, this proposed hypothesis will have to be investigated further.

These results raise some interesting questions regarding the acquisition of the prosodic features of an L2. The capacity for listeners to distinguish languages using only prosodic cues or even just some of the prosodic information is well attested in the literature (Barkat et al. 1999, Ramus & Mehler 1999 among others). However, it is unknown which of these perceived differences is important in the acquisition of an L2. Languages utilize a large range of acoustic variations, and some of these variations carry emotional information. One could then ask which variations are associated with rhythm? Unfortunately, it is difficult (however, not impossible) to identify specific prosodic properties and to investigate them in isolation at this point, as is done in the investigation of segmental oppositions. The results of the present research suggest that duration variations, as a property of the syllable, may continue to be a productive area of investigation.

In addition, the results of the last experiment raise the question as to which one of the durational properties of vowels are learned by English L2 learners. Some of the lengthening rules may be more difficult to perceive or less frequently encountered, hence slowing the acquisition process. As well, it would be interesting to see the effect of motivation and the age of learning on the acquisition of the suprasegmental properties of an L2 (Flege, Munro & MacKay 1996).

H2: A new phonetic category can be established for an L2 sound that differs phonetically from the closest L1 sound if bilinguals discern at least some of the phonetic differences between the L1 and L2 sounds.

H3: The greater the perceived phonetic dissimilarity between an L2 sound and the closest L1 sound, the more likely it is that phonetic differences between the sounds will be discerned.

7.1.2 What are the acoustical properties of French rhythm?

The second goal of the current research was to investigate the nature of linguistic rhythm. It was expected that an examination of the rhythmic properties of an L2 would reveal or confirm the importance of duration as a primary property of rhythm.

Experiment II was designed to investigate the use of duration as a fundamental property of the syllable in the account of French rhythm. Results confirm the hypothesis that attributed greater inter-syllabic variability to English and lower variability to French. In addition, results reveal that the structure of the syllable and the quality of the segments involved have an influence on the amount of inter-syllabic variability found in French. This is taken as empirical support for the integration of language-specific phonological properties in the definition of rhythmic types. Results from Experiment III also support this hypothesis by showing that vocalic segments in the rhythmic structure of French present a greater challenge for English L2 learners.

In addition, Experiment III confirmed the tendencies displayed by EL1 and EL2 speakers in Experiment II, without the ambiguity associated with the assumption that L2 learners have properly acquired French syllable structure in the early stages of acquisition. The hypothesis underlying the use of this methodology in Experiment III was that the perceptual impression which divides languages into two distinct major rhythmic categories is, at least in part, caused by the phonological properties of the languages. This proposal is supported by empirical evidence coming from Dauer (1987), and Ramus et al. (1999). It is likely that the factors identified in Dauer (1987), including syllable structure, the nature of primary and secondary stress, the structure of the syllables which typically bear primary stress, and the use of intonation in a specific language contribute to determining the rhythmic properties of a language. Such a proposal offers the advantage of classifying languages on a

two-dimension continuum, with prototypical stress-timed and syllable-timed languages located in different areas. However, an accurate explanation for the relative position of languages on this continuum must be provided in order to give more credibility to this proposal, and to allow for more accurate analyses.

Another interesting result of the current investigation is the consistent (although not statistically significant) differences observed between CF and EF speakers. In both experiments II and III, EF speakers displayed a greater tendency to syllable-isochrony than CF speakers. In Experiment II, the VarIndex of EF speakers was consistently lower than CF speakers. In Experiment III, EF speakers displayed lower standard deviations than CF speakers. There is ample evidence in the scientific literature that supports the view that the two dialects differ from each other in many respects (Walker 1984, Dumas 1987, Gendron 1966, Santerre 1976, among others).

Even though the experiments conducted for the current research were not designed for the detailed investigation of the dialectal differences in French, they have nevertheless consistently measured differences between EF and CF speakers. Results from Experiment III suggests that some of these differences are related to the phonological system of the two dialects. In fact, this confirms previous claims which attribute a greater use of durational differences in vowel length in CF (Walker 1984:46). These greater variations in duration are found in a broad range of phonemic properties of CF, as in the opposition between /ɛ/ and /ɛ:/ (as in *faite* and *fête*) for instance. Canadian French is also famous for its many diphthongs, which would most certainly affect the average duration of vowels. As well, other phenomena like vowel devoicing, vowel deletion, and vowel laxing almost certainly contribute to a general weakening of the vowel, creating a greater variation in the average vowel duration. Also, the phenomenon of pretonic lengthening presumably had an important influence on the average duration of syllables. In fact, this last

phenomenon is so important in CF that it has been suggested by Armstrong (1999) that CF is "becoming a quantity-sensitive language" (see also Ouellet & Thibault 1996).

7.2 Pedagogical Implications

In light of the findings of the current study, it is possible to identify the following conditions which L2 learners must meet in order to achieve rhythmic proficiency in French:

1) Durational properties of the syllables in learners' speech should approach those produced by native speakers of French;
2) English L2 learners of French must pay particular attention to the durational properties of vowels and to their allophones;
3) By extension of the previous findings, the overall phonological properties of French must be mastered by English L2 learners.

Taken together, these results have some important pedagogical implications for L2 teaching. First, they confirm the role of duration as a key factor in the achievement of a greater level of proficiency. Second, the results highlight the importance of the phonological properties of the TL, thereby suggesting that L2 instructors should consider including allophonic as well as sociolinguistic, dialectal, and stylistic variations in their curriculum.

The most important challenge faced by L2 instructors is to reduce the interference of L1 in order for students to acquire the proper timing properties of the L2. Therefore, the following principles are proposed to L2 instructors who wish to improve their teaching of the rhythmic characteristics of French. The tasks presented below are not limited to the teaching of French and could be applied to the teaching of any other language.

The first principle is the importance of auditory training. Previous research (Rochet 1995 among others) has shown that perceptual training can solve inaccurate production of new segmental oppositions in an L2. In order to reduce interference from L1, it is proposed that a considerable amount of time be spent doing various activities involving auditory training. The auditory stimuli presented to L2 learners will demonstrate the proper rhythmic structure of French from the beginning of their acquisition process.

The second principle involves proper use of decontextualized speech material to introduce the theory of rhythmic structure of French. The advantages of using this type of speech material in the earlier stages of acquisition are twofold. First, it will allow instructors to develop learners' metalinguistic awareness to suprasegmental characteristics of languages in general, and especially to the theory presented. It will also prove helpful in developing learner autonomy, which is a essential skill for the acquisition of an L2. Second, the identification of the most important rhythmic features of the TL is easier with decontextualized speech material, where the number of variables in the stimuli is limited. This is especially true for the teaching of suprasegmental properties of speech which are often the result of a combination of acoustic events. Carefully chosen speech material should allow learners to identify the relevant (and sometimes contrastive) prosodic properties of both L1 and L2. In the teaching of French to L2 English learners, these properties include the different stress patterns (especially on polysyllabic words), the presence or absence of reduced vowels, and the variations in intonation curves.

The third principle emphasizes the importance of presenting more refined suprasegmental properties within their naturalistic context. There is empirical evidence which demonstrates that the acquisition of the fine details of a new segmental opposition in an L2 is done in a context-dependent manner (Rochet 1995). Thus, the more complex rhythmic properties of French

associated with certain speaking styles (Astésano 1999, Guaïtella 1999) and dialects (current study) should be introduced with authentic speech material. This principle would allow learners to become competent in different social settings and would contribute to their better understanding of the socio-cultural and communicative uses of the target language.

Second language instructors will have the responsibility of integrating these principles into their curriculum. In general, the principles proposed above can be applied to a large variety of tasks and in-class activities. The following is a suggestion for possible activities which seem suitable to the application of these principles:

a) As a first step, asking learners to reproduce the rhythmic beats of short phrases by tapping with their fingers, as proposed by Valdman (1993), would be an effective way to introduce learners to rhythmic differences between languages. It is the instructor's responsibility to introduce and summarize the most important aspects of the suprasegmental properties of the TL.
b) As well, nonce words could be used to complement the effect of rhythmic beats. This would reduce semantic interference and would give learners a chance to develop their knowledge of rhythmic properties in polysyllabic words. Learners' metalinguistic awareness can also be developed through careful observation of contrastive speech material. For instance, different stress patterns can be presented using interlingual cognates, like polysyllabic words;
c) More advanced learners could be presented with authentic speech material like phrases and longer speech excerpts. This type of task will help refining the rhythmic structure they will have started acquiring in the previous phases of the acquisition process. Audiovisual material showing native speakers in different settings and situations (at the store, among friends, job interviews, talking to government officials, etc.) can

be used;

d) At this stage, reinforcement can be done through in-class presentations or activities. These activities would enhance the use of different speaking styles in different situations of the real life.

The application of the proposed principles should facilitate L2 learners' acquisition of the rhythmic structure of French which will also help them produce segments with proper duration. As a consequence, their overall listening comprehension and production skills should benefit noticeably from this new approach.

7.3 Limitations of the Current Study

The conclusions drawn from the current research have important theoretical limitations. First, the investigation only examined the use of the parameter of duration in order to account for both English and French rhythm. Most researchers do not believe that the rhythmic properties of both languages can be accounted for using only one parameter. Intonational variations, stress placement, the phenomenon of vowel reduction, the presence of pauses, for instance, are all factors which are likely to have a significant influence on the production of French rhythm.

The second limitation is related to the measurement tools used to assess inter-syllabic variability. The computation of a single index (VarIndex) and the use of consonantal and vocalic intervals provided only a global assessment of the rhythmic properties of the English L2 learners. These tools were not meant to attribute with accuracy the variation observed to any specific property of the L2 learners' speech. Thus, the exact causes of greater variation in the duration of syllables and intervals remains to be determined.

The third limitation is related to the variations measured in the experiments. The investigation could not explain the production of similar inter-

syllabic variability for EL2 speakers in English and French. Clearly, more detailed investigation is needed in order to determine with more accuracy if the more advanced speakers of French do in fact share only one rhythmic structure for both languages.

The experimental approach judged pertinent by the experimenter in this investigation also had several limitations. Acoustical analyses require a significant amount of time in order to gather systematic and accurate measurements. Therefore, the number of speaker groups and the number of speakers in each group had to be limited. As a consequence, the assessment of the participants' acquisition of the French rhythmic properties was not detailed enough to provide a fine description. In addition, the power of the statistical analyses was limited mostly because of the small number of participants in each group.

In order to gain in validity, the analyses should be replicated on a broader sample of speech. This sample should include not only spontaneous speech, but a greater number of sentences in order to account for a greater number of different syllable structures. In addition, more languages should be investigated to validate the tendencies observed in the current research and to answer some of the questions which arose during the analysis.

7.4 Concluding Remarks

The overall goal of this research was to investigate the acquisition of suprasegmental properties of a second language. The experiments have provided evidence which strongly suggests that English L2 learners of French do acquire the temporal rhythmic structure of French. The data also confirm the need to consider syllabic duration when providing an account of rhythmic properties of French. In addition, results of the last experiment suggest that segmental properties of languages or dialects have a noticeable effect on the rhythmic properties of a language.

This investigation successfully measured the degree to which the rhythmic properties of French are acquired by L2 learners. Obviously, more investigations are needed to support these results and the methodology. In addition, many questions remain regarding the acquisition of rhythmic properties of languages. More detailed results should lead to the development of pedagogical material for the teaching of rhythmic properties of French and other languages.

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Appendix A

A1. Form presented to judges in the perceptual experiment

QUESTIONNAIRE POUR PARTICIPANTS FRANCOPHONES DE LANGUE MATERNELLE

Ce questionnaire a pour but d'amasser certaines informations démographiques et linguistiques nécessaires à la réalisation de cette enquête. Les informations fournies seront utilisées uniquement lors des analyses statistiques. Nous nous engageons à ce qu'aucun nom ne soit divulgué lors d'une éventuelle publication des résultats.

Nom: _____

tél/courriel: _____

1. Sexe: M ☐ F ☐

2. Quelle est votre langue maternelle?

_____

3. Quelle est la langue maternelle de vos parents?

mère: _____ père: _____

4. Quelle(s) langue(s) utilisez-vous à la maison?

_____

5. Quelle(s) langue(s) utilisez-vous au travail?

_____

6. Avez-vous grandi dans un milieu bilingue?

Oui ☐ Non ☐

Si oui, à quelles langues étiez-vous exposé(e)?

_____

7. Parlez-vous une (ou plusieurs) autre(s) langue que l'anglais et le français?

Oui ☐ Non ☐

8. Si oui, laquelle (lesquelles), à quelle fréquence et dans quelles circonstances?

Langue	Fréquence	Circonstances
a)		
b)		
c)		
d)		

9. Si vous êtes étudiant(e), dans quel programme êtes-vous inscrit(e)? Si vous travaillez, quel est votre emploi?

_____

10. Savez-vous si vous avez un quelconque problème d'audition? Si oui, lequel?

Oui Non

_____

_____

Je vous demande de porter un jugement subjectif quant au niveau des locuteurs dont vous entendrez des extraits. Cochez le numéro correspondant au niveau du locuteur dans la grille ci-dessous.

	NIVEAU						
	Débutant		Intermédiaire		Avancé		Français natif
LOCUTEURS	1	2	3	4	5	6	7
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

A2. List of Stimuli Presented in Experiment 1

Speaker Groups	Speaker	Sentences
EL1	VR01	Je n'ai pas aimé dessiner les hommes.
	VR02	Non j'étude de être institutrice pour les enfants.
	VR03	...et je veux enseigner français et italien...
	CK01	J'ai une sœur et elle vient de finir ses cours de deuxième année.
	CK02	Mais elle veut devenir professeur d'anglais.
	CK03	Quelque chose pour aider les autres qui n'ont pas beaucoup d'argent, comme euh...
	AL01	J'étais là depuis sept mois je crois à ce moment.
	AL02	Parce que il y avait ma soeur qui travaillait en Écosse.
	AL03	Tous les lacs sont très beaux et les petits montagnes sont bien dans le nord.
EL2	AK01	Le problème c'est que la vie ici est très très pas chère.
	AK02	Et nous avons maintenant un enfant.
	AK03	Je pourrais pas avoir la qualité de vie que j'ai ici.
	CW01	Je me souviens pas des noms des cafés parce que c'était des cafés dans le quartier de l'école.
	CW02	J'y suis allé il y a des années et puis j'y suis allé encore il y a deux années et j'aime beaucoup
	CW03	en général c'est pas souvent que les requins mangent les gens mais je veux pas être mangé moi.
	KB01	Bien sûr à trois ans ils sont mêlés c'est normal même s'ils parlaient une langue là ils seront mêlés c'est comme...
	KB02	Dans le sens qu'ils sont ils sont plus sécuritaires dans le fait d'être francophones qu'il y a disons trente ans.
	KB03	On vient de s'installer dans une nouvelle maison pas loin de la garderie justement pis il aime ça!
CF	HV01	Tu peux à la limite les comparer ça se compare pas tant que ça c'est super beau là mais bon.
	HV02	Je nagerais là pis j'inviterais tout mes amis à faire le party pendant trios semaines avec plein de bière ça serait l'fun.
	HV03	...d'être comme au moins deux mois dans chaque place pour connaître un peu...
	AG01	Quand je suis partie après mon cégep j'ai pris un an off.
	AG02	Ils n'ont pas d'argent pour engager des nouveaux professeurs...
	AG03	...mais je pense que c'est à cause de mes cours de piano que je sais ça...

	VB01	...mais cette année j'ai fait de l'aqua-jogging là...
	VB02	J'ai presque pas pratiqué cette année ça me manque pareil...
	VB03	Ça va faire une belle petite fin de semaine ça fait longtemps que je l'ai pas vu en plus.
EF	VE01	Donc quand ça fond on a vraiment l'impression qu'il y a des cascades.
	VE02	C'était très dur de me réveiller le matin.
	VE03	Euh ... le seul regret que j'ai c'est que je ne parle pas assez anglais ici.
	JD01	Parce qu'il expliquait de façon très technique donc euh ce qu'on lui demandait de faire lors de ses spectacles.
	JD02	Il faudrait que ça se démocratise un petit peu...
	JD03	Donc il traite énormément d'affaires euh là haut quoi.
	MC01	Mais bon il manque toujours les moyens de voyager c'est ça le problème.
	MC02	Ah ils étaient très heureux parce que pour eux c'était l'occasion de voyager.
	MC03	Non on est ... j'ai eu un accident avec mes parents une fois.

A3. ANOVA Table for the Intraclass Correlation: 9 judges

Source of variance	*df*	*Sums of squares*	*Mean Square*	*Estimated Variance Component*
Targets	11	341.213	31.019	.000
Judges	8	4.574	.572	.196
Targers by Judges	88	35.204	.400	

* indicates significance at p≤.05

Computation of the Intraclass Correlation (Shrout 1995:87):

ICC = (TMS – EMS) / (TMS + (k-1) EMS)

Note: TMS, and EMS refer to the target and error Mean Square from the two-way ANOVA based on *n* target and *k* judges.

ICC = (31.019 – 0.4) / (31.019 + (9-1) 0.4) = **0.8948**

A4. Language Background Questionnaire in English

LANGUAGE BACKGROUND QUESTIONNAIRE
FOR ENGLISH L2 LEARNERS OF FRENCH

This questionnaire will gather linguistic information which will be used for the analyses in this experiment. Under no circumstances will your name be revealed in any publication.

(do not write anything)
code: _____

Name: _____

tel/email: _____

1. Sex. Please, indicate which category you belong to (☑):

M ☐ F ☐

2. Age. Please, indicate which category you belong to (☑):

18-25 ☐ 26-30 ☐ 31-35 ☐ 36- + ☐

3. What is your first language? _____

4. What is your parents' first language?

mother:_____ father:_____

5. Do you speak any other language than English and French? If so, please indicate which one(s).

_____

6. How old were you when you started studying French?

_____

7. How long have you been studying French?

_____

8. Where did you study French?

_____

9. Have you ever been enrolled in French immersion? If so, where and for how long?

Yes: _____ where: _____ how long: _____

10. Do you use French outside of classes? If so, under what circumstances and how often?

Yes ☐ No ☐

_____

_____

_____

12. To the best of your knowledge, are you aware of any hearing problem you may have? If so, which one?

Yes No

_____

13. If you are a student, in which program are you enrolled at the University of Alberta? If you are working, what is your job title?

_____

A5. Language Background Questionnaire in French

QUESTIONNAIRE POUR PARTICIPANTS FRANCOPHONES DE LANGUE MATERNELLE

Ce questionnaire a pour but d'amasser certaines informations démographiques et linguistiques nécessaires à la réalisation de cette enquête. Les informations fournies seront utilisées uniquement lors des analyses statistiques. Nous nous engageons à ce qu'aucun nom ne soit divulgué lors d'une éventuelle publication des résultats.

(ne pas remplir cette section)
code: _____

Nom: _____

tél/courriel: _____

1. Sexe: M ☐ F ☐

2. Âge (choisissez la classe à laquelle vous appartenez): (☑)

18-25 ☐ 26-30 ☐ 31-35 ☐ 36- + ☐

3. Avez-vous le français comme langue maternelle? (☑)

Oui ☐ Non ☐

4. Quelle est la langue maternelle de vos parents?

mère: _____ père: _____

5. Quelle(s) langue(s) utilisez-vous à la maison?

_____

6. Avez-vous grandi dans un milieu bilingue?

Oui ☐ Non ☐

7. Parlez-vous une ou plusieurs autre(s) langue(s) que l'anglais et le français?

Oui Non

8. Si oui, laquelle (lesquelles), à quelle fréquence et dans quelles circonstances?

Langue	Fréquence	Circonstances
a)		
b)		
c)		

9. Depuis combien de temps estimez-vous être dans un milieu majoritairement anglophone?

_____

10. Est-ce que la majorité de vos activités journalières (études, travail) se déroule en français? Si non, dans quelle langue?

Oui ☐ Non ☐_____

11. Si vous êtes étudiant(e), dans quel programme êtes-vous inscrit(e)? Si vous travaillez, quelle est votre emploi?

_____

12. Savez-vous si vous avez un quelconque problème d'audition? Si oui, lequel?

Oui Non

_____

Appendix B

B1. ANOVA Table for the Analysis of the French Corpus Using the Variability Index

Source of Variance	*Sum of Squares*	*df*	*Mean Square*	*F-ratio*	*Sign.*
Rhythmic Group	.0702	2	.03510	.134	.875
Speaker Group	.656	3	.219	5.287	.011*
Sentence (R.Group)	4.127	15	.275	6.340	.000*
Speaker (Sp.Group)	.189	8	.02358	2.007	.112
Rhythmic Group x Speaker Group	.204	6	.03405	1.153	.379
Speaker Group x Sentence (R.Group)	1.953	45	.04340	1.695	.012*
R.Group x Speaker (Sp.Group)	.188	16	.01175	.459	.962

* indicates significance at p≤.05

B2. Table for the Tukey HSD Post-Hoc Test

		EF	CF	EL2	EL1
		0.2866	*0.3508*	*0.4056*	*0.4298*
EF	*0.2866*		2.3194	4.299*	5.173*
CF	*0.3508*			1.9798	2.854
EL1	*0.4056*				0.8743
EL2	*0.4298*				

* indicates significance at p≥.05
(k=4, d.f. of Ms $_{error}$ = 14.652, Q_{ψ} = 0.0277, H.S.D. = 4.11)

B3. Table for the Tukey HSD Post-Hoc Test

		R1S6	R2S2	R1S4	R3S6	R2S6	R3S2	R3S3	R2S3	R1S5	R2S4	R3S5	R3S1	R1S3	R1S2	R3S4	R2S5	R2S1	R1S1
		0.21	*0.23*	*0.23*	*0.26*	*0.28*	*0.28*	*0.31*	*0.32*	*0.32*	*0.32*	*0.33*	*0.37*	*0.37*	*0.38*	*0.51*	*0.54*	*0.63*	*0.72*
R1S6	*0.21*	0.00	0.50	0.64	1.54	2.19	2.25	3.08	3.41	3.49	3.60	3.85	5.01	5.22	5.53*	9.75*	10.46*	13.59*	16.52*
R2S2	*0.23*		0.00	0.14	1.04	1.69	1.75	2.58	2.91	3.00	3.10	3.35	4.51	4.72	5.03	9.25*	9.96*	13.09*	16.02*
R1S4	*0.23*			0.00	0.90	1.55	1.61	2.44	2.77	2.86	2.97	3.21	4.37	4.58	4.89	9.11*	9.82*	12.95*	15.88*
R3S6	*0.26*				0.00	0.65	0.71	1.54	1.87	1.95	2.06	2.31	3.47	3.68	3.99	8.21*	8.92*	12.05*	14.98*
R2S6	*0.28*					0.00	0.06	0.89	1.22	1.31	1.42	1.66	2.82	3.03	3.34	7.56*	8.27*	11.40*	14.33*
R3S2	*0.28*						0.00	0.83	1.16	1.25	1.36	1.60	2.76	2.97	3.28	7.50*	8.21*	11.34*	14.27*
R3S3	*0.31*							0.00	0.33	0.42	0.53	0.77	1.94	2.14	2.45	6.67*	7.38*	10.52*	13.45*
R2S3	*0.32*								0.00	0.09	0.20	0.44	1.60	1.81	2.12	6.34*	7.05*	10.18*	13.11*
R1S5	*0.32*									0.00	0.11	0.35	1.52	1.73	2.04	6.25*	6.97*	10.10*	13.03*
R2S4	*0.32*										0.00	0.24	1.41	1.62	1.93	6.14*	6.86*	9.99*	12.92*
R3S5	*0.33*											0.00	1.16	1.37	1.68	5.90*	6.61*	9.74*	12.67*
R3S1	*0.37*												0.00	0.21	0.52	4.73	5.45*	8.58*	11.51*
R1S3	*0.37*													0.00	0.31	4.52	5.24	8.37*	11.30*
R1S2	*0.38*														0.00	4.22	4.93	8.06*	10.99*
R3S4	*0.51*															0.00	0.71	3.85	6.78*
R2S5	*0.54*																0.00	3.13	6.06*
R2S1	*0.63*																	0.00	2.93
R1S1	*0.72*																		0.00

* indicates significance at $p \geq .05$

($k=18$, d.f. of $Ms_{error} = 45$, $Q_{\psi} = 0.0311$, H.S.D. = 5.27)

B4. ANOVA Table for the Analysis of the French Corpus Using the Variability Index

Source	*Sum of Squares*	*df*	*Mean Square*	*F-ratio*	*Sign.*
Rhythmic Group	.0639	2	.03192	.133	.877
Speaker Group	.468	3	.156	4.248	.022*
Sentence (R.Group)	3.822	15	.255	5.855	.000*
Speaker (Sp.Group)	.142	8	.01769	1.811	.149
Rhythmic Group x Speaker Group	.225	6	.03756	1.303	.312
Speaker Group x Sentence (R.Group)	1.958	45	.04352	1.779	.007
R.Group x Speaker (Sp.Group)	.156	16	.0977	.399	.980

* indicates significance at p≤.05

B5. Table for the Tukey HSD Post-Hoc Test

	EF *0.2866*	CF *0.3508*	EL2 *0.4056*	EL1 *0.4298*
EF		2.5103	3.9260	5.1523*
CF			1.9798	2.6420
EL1				1.2263
EL2				

* indicates significance at p≥.05
(k=4, d.f. of Ms $_{error}$ = 13.286, Q_{ψ} = 0.0243, H.S.D. = 4.11)

B6. ANOVA Table for the Analysis of the French Corpus Using the Variability Index

Source	*Sum of Squares*	*df*	*Mean Square*	*F-ratio*	*Sign.*
Syllable	42.705	4	10.676	20.426	.000*
Speaker Group	.0994	3	.0331	.964	.427
Sentence (Syllable)	12.522	25	.501	9.395	.000*
Speaker (Sp.Group)	.0688	8	.860	.174	.993
Syllable x Sp.Group	4.229	12	.352	4.693	.000*
Sp.Group x Sentence (Syllable)	3.998	75	.0533	1.936	.000*
Syllable x Speaker (Sp.Group)	1.578	32	.0493	1.791	.009*

* indicates significance at p≤.05

B7: Table for the Tukey HSD Post-Hoc Test

		S3 *0.64*	S2 *0.695*	S4 *0.885*	S5 *1.055*	S1 *1.598*
S3	*0.64*		0.6455	2.8756	4.8709*	11.2441*
S2	*0.695*			2.2301	4.2254*	10.5986*
S4	*0.885*				1.9953	8.3685*
S5	*1.055*					6.3732*
S1	*1.598*					

* indicates significance at $p \geq .05$
($k=5$, d.f. of $Ms_{error} = 27.007$, $Q_{\psi} = 0.0852$, H.S.D. = 3.90)

B8: Table for the Tukey HSD Post-Hoc Test

		S3T1	S3T5	S4T3	S2T4	S2T3	S3T6	S5T4	S2T2	S4T1	S3T2	S4T2	S2T6	S4T5	S3T3	S3T4	S2T5	S2T1	S4T6	S5T6	S4T4
		0.54	0.55	0.57	0.57	0.58	0.59	0.62	0.63	0.65	0.67	0.69	0.69	0.74	0.75	0.75	0.82	0.88	0.94	0.94	1.12
S3T1	0.54		0.17	0.45	0.51	0.68	0.77	1.23	1.43	1.64	2.00	2.24	2.25	3.02	3.23	3.24	4.31	5.23	6.08*	6.08*	8.69*
S3T5	0.55			0.29	0.35	0.51	0.60	1.07	1.26	1.47	1.83	2.07	2.09	2.85	3.06	3.08	4.14	5.06	5.92*	5.92*	8.53*
S4T3	0.57				0.06	0.23	0.32	0.78	0.98	1.19	1.55	1.79	1.80	2.57	2.78	2.79	3.86	4.77	5.63*	5.63*	8.24*
S2T4	0.57					0.17	0.26	0.72	0.92	1.13	1.49	1.73	1.74	2.51	2.72	2.73	3.80	4.71	5.57*	5.57*	8.18*
S2T3	0.58						0.09	0.56	0.75	0.96	1.32	1.56	1.58	2.34	2.55	2.57	3.63	4.55	5.41	5.41	8.02*
S3T6	0.59							0.47	0.66	0.87	1.23	1.47	1.49	2.25	2.46	2.48	3.54	4.46	5.32	5.32	7.93*
S5T4	0.62								0.20	0.41	0.77	1.01	1.02	1.79	2.00	2.01	3.08	3.99	4.85	4.85	7.46*
S2T2	0.63									0.21	0.57	0.81	0.83	1.59	1.80	1.82	2.88	3.80	4.65	4.65	7.27*
S4T1	0.65										0.36	0.60	0.62	1.38	1.59	1.61	2.67	3.59	4.44	4.44	7.06*
S3T2	0.67											0.24	0.26	1.02	1.23	1.25	2.31	3.23	4.08	4.08	6.70*
S4T2	0.69												0.02	0.78	0.99	1.01	2.07	2.99	3.84	3.84	6.46*
S2T6	0.69													0.77	0.98	0.99	2.06	2.97	3.83	3.83	6.44*
S4T5	0.74														0.21	0.23	1.29	2.21	3.06	3.06	5.68*
S3T3	0.75															0.02	1.08	2.00	2.85	2.85	5.47
S3T4	0.75																1.07	1.98	2.84	2.84	5.45
S2T5	0.82																	0.92	1.77	1.77	4.38
S2T1	0.88																		0.86	0.86	3.47
S4T6	0.94																			0.00	2.61
S5T6	0.94																				2.61
S4T4	1.12																				
S5T5	1.12																				
S5T2	1.17																				
S5T1	1.21																				
S5T3	1.27																				
S1T6	1.32																				
S1T1	1.34																				
S1T5	1.60																				

S1T2	1.63																				
S1T4	1.82																				
S1T3	1.89																				

(cont'd)

S5T5	S5T2	S5T1	S5T3	S1T6	S1T1	S1T5	S1T2	S1T4	S1T3
1.12	1.17	1.21	1.27	1.32	1.34	1.60	1.63	1.82	1.89
8.78°	9.58°	10.14°	10.98°	11.79°	12.04°	15.93°	16.37°	19.28°	20.29°
8.62°	9.41°	9.97°	10.81°	11.62°	11.88°	15.77°	16.20°	19.11°	20.12°
8.33°	9.13°	9.68°	10.53°	11.34°	11.59°	15.48°	15.92°	18.83°	19.83°
8.27°	9.07°	9.62°	10.47°	11.28°	11.53°	15.42°	15.86°	18.77°	19.77°
8.11°	8.90°	9.46°	10.30°	11.11°	11.37°	15.26°	15.69°	18.60°	19.61°
8.02°	8.81°	9.37°	10.21°	11.02°	11.28°	15.17°	15.60°	18.51°	19.52°
7.55°	8.35°	8.90°	9.74°	10.56°	10.81°	14.70°	15.14°	18.05°	19.05°
7.36°	8.15°	8.71°	9.55°	10.36°	10.62°	14.50°	14.94°	17.85°	18.86°
7.15°	7.94°	8.50°	9.34°	10.15°	10.41°	14.29°	14.73°	17.64°	18.65°
6.79°	7.58°	8.14°	8.98°	9.79°	10.05°	13.93°	14.37°	17.28°	18.29°
6.55°	7.34°	7.90°	8.74°	9.55°	9.80°	13.69°	14.13°	17.04°	18.05°
6.53°	7.33°	7.88°	8.72°	9.53°	9.79°	13.68°	14.11°	17.03°	18.03°
5.77°	6.56°	7.12°	7.96°	8.77°	9.02°	12.91°	13.35°	16.26°	17.27°
5.56	6.35°	6.91°	7.75°	8.56°	8.81°	12.70°	13.14°	16.05°	17.06°
5.54	6.34°	6.89°	7.73°	8.54°	8.80°	12.69°	13.12°	16.04°	17.04°
4.47	5.27	5.83°	6.67°	7.48°	7.73°	11.62°	12.06°	14.97°	15.98°
3.56	4.35	4.91	5.75°	6.56°	6.82°	10.71°	11.14°	14.05°	15.06°
2.70	3.50	4.05	4.89	5.71°	5.96°	9.85°	10.29°	13.20°	14.20°
2.70	3.50	4.05	4.89	5.71°	5.96°	9.85°	10.29°	13.20°	14.20°
0.09	0.89	1.44	2.28	3.09	3.35	7.24°	7.67°	10.59°	11.59°
	0.80	1.35	2.19	3.00	3.26	7.15°	7.58°	10.50°	11.50°
		0.56	1.40	2.21	2.46	6.35°	6.79°	9.70°	10.71°
			0.84	1.65	1.91	5.80°	6.23°	9.14°	10.15°
				0.81	1.07	4.95	5.39	8.30°	9.31°
					0.26	4.14	4.58	7.49°	8.50°
						3.89	4.32	7.24°	8.24°
							0.44	3.35	4.35
								2.91	3.92

									1.01

* indicates significance at p≥.05
(k=30, d.f. of Ms $_{error}$ = 27.007, Q_{ψ} = 0.0852, H.S.D. = 3.90)

B9: Table for the Tukey HSD Post-Hoc Test

		S3G4	S3G3	S2G1	S3G2	S2G2	S3G1	S2G3	S2G4	S4G3	S4G4	S5G4	S4G2	S4G1	S5G3	S5G1	S5G2	S1G1	S1G2	S1G3	S1G4
		0.61	0.61	0.61	0.61	0.66	0.73	0.73	0.78	0.78	0.78	0.96	0.97	1.01	1.06	1.10	1.10	1.37	1.46	1.69	1.87
S3G4	0.61		0.01	0.03	0.03	0.78	1.92	1.94	2.65	2.67	2.68	5.51*	5.56*	6.19*	7.02*	7.53*	7.60*	11.80*	13.10*	16.81*	19.56*
S3G3	0.61			0.02	0.02	0.76	1.90	1.93	2.63	2.66	2.66	5.50*	5.55*	6.18*	7.01*	7.52*	7.59*	11.78*	13.09*	16.80*	19.55*
S2G1	0.61				0.00	0.74	1.89	1.91	2.61	2.64	2.65	5.48*	5.53*	6.16*	6.99*	7.50*	7.57*	11.77*	13.07*	16.78*	19.53*
S3G2	0.61					0.74	1.88	1.91	2.61	2.64	2.64	5.48*	5.53*	6.16*	6.99*	7.50*	7.57*	11.76*	13.07*	16.78*	19.53*
S2G2	0.66						1.14	1.17	1.87	1.90	1.90	4.74	4.78	5.42*	6.25*	6.75*	6.82*	11.02*	12.33*	16.04*	18.79*
S3G1	0.73							0.02	0.73	0.76	0.76	3.60	3.64	4.28	5.11	5.61*	5.68*	9.88*	11.19*	14.90*	17.65*
S2G3	0.73								0.70	0.73	0.74	3.57	3.62	4.25	5.08	5.59*	5.66*	9.86*	11.16*	14.87*	17.62*
S2G4	0.78									0.03	0.03	2.87	2.91	3.55	4.38	4.88	4.95	9.15*	10.46*	14.17*	16.92*
S4G3	0.78										0.00	2.84	2.89	3.52	4.35	4.86	4.93	9.13*	10.43*	14.14*	16.89*
S4G4	0.78											2.84	2.88	3.52	4.35	4.85	4.92	9.12*	10.43*	14.14*	16.89*
S5G4	0.96												0.05	0.68	1.51	2.02	2.09	6.28*	7.59*	11.30*	14.05*
S4G2	0.97													0.63	1.46	1.97	2.04	6.24*	7.54*	11.25*	14.00*
S4G1	1.01														0.83	1.34	1.41	5.61*	6.91*	10.62*	13.37*
S5G3	1.06															0.51	0.58	4.78	6.08*	9.79*	12.54*
S5G1	1.10																0.07	4.27	5.57*	9.28*	12.03*
S5G2	1.10																	4.20	5.50*	9.22*	11.96*
S1G1	1.37																		1.30	5.02	7.76*
S1G2	1.46																			3.71	6.46*
S1G3	1.69																				2.75
S1G4	1.87																				

* indicates significance at p≥.05
(k = 20, d.f. of Ms $_{error}$ = 47.917, Q_{ψ} = .0646, H.S.D. = 5.27)

Speaker Groups are: G1 (EL1), G2 (EL2), G3 (CF), and G4 (EF).

B10. ANOVA Table for the Analysis of the French Corpus, Free Speech

Source	*Sum of Squares*	*df*	*Mean Square*	*F-ratio*	*Sign.*
Between Groups	.1628	2	.0814	4.4066	.0158*
Within Groups	1.2745	69	.0185		
Total	1.4373	71			

* indicates significance at p≤.05

Appendix C

C1. ANOVA Table for the analysis of %V

Source of variance	*df*	*Sums of squares*	*Mean Square*	*Estimated Variance Component*
Speaker Groups	3	51.423	6.792	.014
Speakers (SpkrGroups)	8	7.571	.250	.978

C2. Table for the Tukey LSD Post-Hoc test:

LSD	1	2	4.7126*	.043
		3	3.9752	.085
		4	2.8213	.218
	2	1	-4.7126*	.043
		3	-.7371	.745
		4	-1.8914	.406
	3	1	-3.9752	.085
		2	.7374	.745
		4	-1.1539	.611
	4	1	-2.8213	.218
		2	1.8914	.406
		3	1.1539	.611

* The mean difference is significant at the .05 level.

C3. ANOVA Table for the analysis of ΔV:

Source of variance	*df*	*Sums of squares*	*Mean Square*	*Estimated Variance Component*
Speaker Groups	3	6.332E-03	2.107E-03	.100
Speakers (SpkrGroups)	8	5.765E-03	7.206E-04	.178

C4. Table for the Tukey HSD Post-Hoc test:

Tukey HSD	1	2	2.15832E-02*	.087
		3	2.36041E-02	.052
		4	3.07463E-02	.007
	2	1	-2.1583E-02	.087
		3	2.02085E-03	.996
		4	9.16303E-03	.729
	3	1	-2.3604E-02	.052
		2	-2.0209E-03	.996
		4	7.14218E-03	.850
	4	1	-3.0746E-02*	.007
		2	-9.1630E-03	.729
		3	-7.1422E-03	.850

* The mean difference is significant at the .05 level.

C5. Two-Way ANOVA Table for the analysis of ΔC:

Source of variance	*df*	*Sums of squares*	*Mean Square*	*Estimated Variance Component*
Speaker Groups	3	3.320E-04	E1.107-04	.848
Speakers (SpkrGroups)	8	3.324E-03	4.155E-04	.311

C6. Table for the Tukey HSD Post-Hoc test:

Tukey HSD	1	2	6.69180E-03	.809
		3	5.36849E-03	.890
		4	5.86394E-03	.862
	2	1	-6.6918E-03	.809
		3	-1.3233E-03	.998
		4	-8.2785E-03	1.000
	3	1	-5.3685E-03	.890
		2	1.32331E-03	.998
		4	4.95454E-03	1.000
	4	1	-5.8639E-03	.862
		2	8.27853E-03	1.000
		3	-4.9545E-03	1.000

* The mean difference is significant at the .05 level.